Field Crop Production Guide

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CROP PRODUCTION

Successful crop production depends on a number of inter-related factors. Keep this in mind when making decisions on production inputs. Factors to be considered include:

- seed bed type and preparation
- seed variety and quality
- seed treatment
- seeding method and timing
- fertilizer application
- pest management, including weeds, insects and diseases
- harvesting method

In general, expect best results when the proper balance of inputs is tailored to the particular soil and climatic conditions involved. For example, maximum returns from good quality seed and fertilizer are reached only when integrated with other management practices such as effective pest control measures.

For variety selection, refer to the current issue of *Seed Manitoba*.

Assess management practices and production costs carefully to select the optimum crop combination that will maximize profits. To assist producers in deciding which crops to grow, Manitoba Agriculture and Food has produced *Guidelines for Estimating Crop Production Costs*. These brochures are published annually and estimate the production costs for several different crops. They are available from your local agricultural representative.

CROP ROTATIONS

Alternating broadleaf and cereal crops is generally recommended; specific cases are discussed under individual crop sections. Further information on crop rotation can be obtained from Manitoba Agriculture and Food *Crop Rotation Chart*.

USE OF GOOD SEED

Always use good, preferably pedigreed, seed of a recommended variety. Pedigreed seed consistently outyields common seed. Thorough cleaning removes weed seeds and most diseased kernels and retains only the large kernels that produce larger, more vigorous plants.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) involves reducing pests to tolerable levels, allowing agriculture to remain productive and profitable while minimizing health and environmental risks. The elements of an IPM program are:

- Collect specific field information, such as rotations, fertilizer applications and previous pesticide applications
- Establish and maintain a good record-keeping system
- Identify potential pests
- Establish monitoring/scouting procedures
- Establish injury levels/economic thresholds
- Apply corrective action to maintain pest populations below threshold levels
- Evaluate the effects and effectiveness of pest control measures

Each step of an IPM program is unique and requires input based on individual situations. Determining the incidence and distribution of major pests and beneficial insects in a crop is the first step in the development of an IPM strategy. To assist growers in making pest management decisions, Manitoba Agriculture and Food has developed a *Field Scouting Guide*. At the beginning of each section in the book, there is a brief discussion of proper scouting techniques for insects, weeds and diseases. The *Field Scouting Guide* is available from the Soils and Crops Branch of Manitoba Agriculture and Food. Manitoba Agriculture and Food also produces a *Guide to Crop Protection*, which contains current information on economic thresholds, pesticide resistance updates and pesticide recommendations. The *Guide to Crop Protection* is available from your local agricultural representative office (or MAF website).

IPM involves the careful use of management tools, such as using pesticides only when numbers or damage exceed economic thresholds (i.e. when yield loss is greater in value than the cost of chemical and its application). In recent years, some agricultural pests have developed resistance to herbicides, insecticides and fungicides. Resistance develops as a result of repeated use of one or more pesticides with the same mode of action over a number of years.

Producers should follow management practices that prevent or minimize the development of resistance. These include the rotation of both crops and pesticides. Use products with different modes of action when rotating pesticides. Crop rotation is recommended as a management tool, and specific cases are discussed under individual crop sections. Additional information on crop rotation can be obtained from the *Crop Rotation Chart* produced by Manitoba Agriculture and Food, as well as the *Guide to Crop Protection*.

For further information on disease, insect and weed control strategies, these and other fact sheets can be obtained from Manitoba Agriculture and Food:

- Orange Wheat Blossom Midge
- Flea Beetle Management
- Bertha Armyworm
- Diamondback Moth
- Dealing with Fusarium Head Blight
- Managing Cereal Leaf Diseases
- Integrated Management of Leafy Spurge

For copies of this information or for additional resources contact your local agricultural representative or visit our home page at:
http: //www.gov.mb ca/agriculture/

ORGANIC PRODUCTION

Organic crop production is a system of farming based on ecological principles. One formal definition states that, "Organic farming seeks to create ecosystems that achieve sustainable productivity and provide control of pests through a diverse mix of mutually-dependent life forms, through recycling of plant and animal residues, and through crop selection, crop rotation, water management and cultivation. Soil fertility is maintained and enhanced by a system which optimizes soil biological activity as the means to providing nutrients for plant and animal life as well as to conserve soil resources."

A crop cannot be marketed as "certified organic" in Manitoba until the land on which it is grown has been free of synthetic fertilizers and pesticides for at least three years prior to crop harvest. The third harvest on the land can therefore be recognized as an organic product.

The primary challenges in an organic crop production system include:

1. Fertility
2. Weed Management
3. Insect Management
4. Disease Management
5. Soil Conservation

Fertility

Soil testing on a regular basis is an important tool in the management of an organic cropping system. As well as providing the grower with an approximate level of nutrients in the soil, a soil test can help to measure the benefit of various agronomic practices over a number of years.

There are several products and practices that will supply nutrients organically:

- application of composted animal manure
- green manure plow-downs
- inclusion of legumes in the crop rotation
- alternating high and low-nutrient demand crops
- alternating deep and shallow-rooted crops
- use of certain fertilizers (from the list of permitted inputs)
- use of certain microbial inoculants (from the list of permitted inputs)
- summerfallow (releases nutrients from soil organic matter)

Weed Management

Effective weed management depends on a thorough understanding of the biology and growth habit of the species in question. In most cases, a combination of a number of cultural and preventative practices will be required to effectively deal with weeds:

- field and crop sanitation
- crop rotations
- crop competition (which includes the variables of crop selection, seeding date, seeding rate, row spacing, seeding depth and plant nutrition)
- both out-of-crop and in-crop tillage
- use of plants with beneficial allelopathic effects
- mowing and burning
- biological controls

Insect Management

As with weed management, successful insect control will depend on jointly incorporating a number of control strategies:

- diverse crop rotations
- field and crop sanitation
- weed management
- seeding date and seeding rate
- management of summerfallow and stubble
- seeding trap strips
- balanced soil nutrition
- resistant cultivars
- biological controls

Disease Management

Plant disease control measures are aimed at reducing or eliminating one of the three factors involved in disease development: an infectious pathogen, a susceptible host and a suitable environment. Not only do these factors interact, but disease control strategies also must be woven together with management methods to address weed, insect and other production concerns.

Considerations in disease management should include:

- rotation of susceptible and resistant crops
- the use of resistant cultivars
- field sanitation: managing disease-infected straw, stubble, chaff and volunteer plants
- seed sanitation: using uncracked and disease-free seed
- planting dates, rates and depth
- maintaining balanced soil nutrient levels, including both macronutrients and micronutrients
- the use of livestock manure to stimulate higher populations of soil microorganisms
- incorporation of green manure cover crops

Soil Conservation

As in other farming systems, the challenge in the organic system is to employ soil conservation practices that are best adapted to each particular farm. Although practices that use herbicides are not an option, attempts are made to not use tillage any more often than in conventional systems. Therefore, the organic crop producer may need to use a combination of effective soil conservation measures. These may include:

- optimizing the use of crop residues to replenish soil organic matter and improve soil properties such as water infiltration, water storage and particle aggregation
- limiting tillage depth, speed and the number of operations in order to conserve crop residue and soil moisture
- appropriate stubble height
- direct seeding
- extending crop rotations to reduce summerfallow
- using wind barriers such as annual crops, perennial grasses and shelterbelts in crop or summerfallow situations.
- strip-cropping at an angle perpendicular to the prevailing wind direction
- using cover crops to protect the soil from wind and water erosion during certain vulnerable periods
- incorporating green manure to improve soil quality
- effective use of animal manure

SOIL QUALITY

Good soil health makes economic and environmental sense. Soil erosion and salt buildup must be prevented. The following are considered good soil management practices.

Avoid Summerfallow

Continuous cropping makes more efficient use of water and significantly reduces the chance of soil erosion and salinity.

Rotate Crops

Alternate cereals like wheat with annual legumes like peas or lentils and other broadleaf crops such as canola. Perennial forage crops such as alfalfa can greatly improve soil health.

Use Reduced or Zero Tillage

Zero tillage (or direct seeding) involves the planting of a crop into untilled stubble of a previous crop. This system uses crop rotation and herbicides to control weeds. All crops except tuber and root crops can be produced in this fashion. Zero tillage eliminates soil erosion, saves moisture, and reduces fuel, labor and maintenance costs. Zero tillage can be practised on all soil types. However, wet, heavy clays are more difficult to manage without tillage.

Zero tillage crop production systems are designed around the following operations.

1. ***Crop Rotation*** – Crops with different characteristics should be grown. Alternate high residue - producing crops such as wheat, barley, corn and oats with low-residue producing crops such as lentils, dry beans, flax and buckwheat. Grow winter wheat or fall rye to improve weed management. Rotate cereal and broadleaf crops to manage disease.
2. ***Crop Residue Management*** – Straw and chaff must be chopped and evenly spread during harvest, or baled after harvest, to allow for proper seeding. Stubble height should not exceed the row width of the seeder. A chaff spreader should be added to the combine. Chaff can also be collected and fed to livestock.
3. ***Weed Control*** – Use crop rotation as much as possible to help manage weeds. In addition, a non-selective herbicide is used to control weeds before seeding, between seeding and crop emergence, pre-harvest and after harvest. Winter annual weeds (stinkweed, shepherd's purse and flixweed) are best controlled in the fall with herbicides. Perennial weeds (quackgrass, Canada thistle) are best controlled by pre-harvest or fall application of registered herbicides. In-crop herbicides can be used as a follow up. All herbicides should be rotated according to their mode of action to avoid the development of weed resistance.
4. ***Fertility*** – Use a soil test to accurately determine fertility requirements. Moisture savings from zero tillage can result in increased yield, so the higher recommended rates of fertilizer may be needed to optimize fertilizer use. Depending on seeding equipment, fertilizers may be applied at the time of seeding in the seed row or in a band alongside the seed row. There are limits to the amount of fertilizer that can be applied in the seed row without injuring the crop. Do not apply anhydrous ammonia directly to the seed row. Fertilizer can also be banded in a separate operation to maximize crop safety.

Use low-disturbance banding equipment such as knives or spoke injectors. Ammonium nitrate can be broadcast-applied, but this method is not recommended for urea-based fertilizers as nutrient losses can be substantial.

5. ***Seed Placement*** – With good residue management, seed drills and air seeders designed for zero tillage give excellent seed placement. Seed should be placed more shallow than in tilled seed beds (1.0 to 1.5 inches). At these depths, moisture and temperatures are sufficient to allow gemination. Seeding too deep delays crop emergence. On-row packing improves seed-soil contact and improves crop establishment.

Reduced tillage refers to the least amount of tillage required to create a good seed bed. This tillage system leaves sufficient ground cover (50 per cent on clays and silts, 65-75 per cent on sandy loams and sands) to prevent soil erosion throughout the period when no crop is growing. Adequate trash cover is best achieved by eliminating fall tillage and, instead, controlling weeds with a late fall application of a registered herbicide.

There are numerous options for reduced tillage, depending on the tillage equipment available.

The amount of residue remaining increases with decreased depth and lower tillage speed. Tillage after low-residue crops such as lentils and field beans should be avoided or limited to one pass.

Use shelterbelts and cover crops

Especially where potatoes or vegetable crops are grown, plant permanent shelterbelts and sow fall cover crops such as fall rye after harvest.

Table 1. Crop residue left after different implement operations.

Crop residue left after each implement operation	
Tillage Implement	**Per cent crop residue**
Wide blade cultivator (36" blades)	90
Rod weeder	90
Field cultivator (9-12" sweeps)	80
Field cultivator with harrows	60
HD cultivator (16-18" sweeps)	75
HD cultivator with rodweeder	80
HD cultivator with harrows	60
One-way disc	50
Tandem disc-offset disc	50
Moldboard plow	10
Disc drill	85
Hoe drill	80
Air seeder, shovel openers	80
Air seeder, knife openers	90
Air seeder, harrows/packers	60
Fertilizer injector	85
Harrows	90
Coil packer	95
Tine harrows and packer	85

Avoid Burning Stubble

Provincial regulations control when stubble burning is permitted based on weather conditions. Managing straw, using tillage, harrowing or baling, is preferred over burning.

Keep Natural Wetlands

Draining wetlands removes important habitat and alters natural drainage patterns. Often, drained soil becomes too saline to support crop production.

SEEDING BY PLANT POPULATION

Seeding rates are usually given in bu/acre; however, a preferred method to determine optimum seeding rates is to consider final plant stands or plant populations. This method takes into account the desired plant stand, the variety seed size (thousand kernel weight) and the expected seed survival.

$$\text{Seeding Rate (lb/acre)} = \frac{\text{desired plants/ft}^2 \times \text{TKW (g)}}{\text{\% expected seed survival*} \times 10}$$

**Expected seedling survival used in decimal form (90% = 0.9)*

The desired plant population (plants/ft^2) varies depending on the crop. For specific populations see the Seeding section of each crop.

The 1,000 kernel weight is measured simply by counting out 1,000 seeds and weighing them in grams (g). Seed weights vary between varieties, fields, crop types and from year to year.

For large seeded crops where the seeds/lb is already known, this can be converted to1,000 kernel weight (TKW) by the following formula:

$$TKW = \frac{1000 \times \text{seeds/lb}}{454}$$

Expected seed survival is the germination less a small amount for seedling mortality. For example, under normal conditions expect approximately 95 per cent survival of the germinating seeds. However, if planting in unfavourable conditions, i.e., cold, wet soil, expect approximately 90-93 per cent survival.

Example:

desired plant stand = 25 plants/ft^2
thousand kernel weight = 40 g
germination = 90 per cent
expected seed survival (good conditions) = .95 x .90 = .86

$$\textit{Seeding rate} = \frac{25 \times 40}{.86 \times 10} = 116 \text{ lb/acre}$$

Seeding Drill Calibration

Once the desired seeding rate is calculated, the next step is to calibrate the seed drill so that it drops the right amount of seed. The following steps tell you how many grams of seed should be collected from one drill run after driving a specified distance.

1. Calculate expected output per run of your seed drill over a measured distance.

   Method a)

   $$\text{Seed (g/100 ft of row with 6" row spacing)} = \frac{\text{seeding rate (lb/acre)}}{2}$$

   $$\text{Number of seeds/100 ft of row} = \frac{\text{seed (g/100 ft of row)} \times 1{,}000}{\text{TKW (g)}}$$

   Example:

   $$\frac{116/2 = 58 \text{ g.} \quad 58 \times 1000}{40} = 1450 \text{ seeds}$$

   Method b)

   $$\text{Number of seeds/ft of row} = \frac{\text{desired plant population} \times \text{row spacing}}{\text{\% expected seed survival} \times 12}$$

   **Expected seedling survival used in decimal form (90% = 0.9)*

   Example:

   $$\frac{25 \times 6}{.86 \times 12} = \frac{25}{1.72} = 14.5 \text{ seeds}$$

2. Tie collecting bag over the outlet from one drill run.
3. Drive a measured distance (i.e., 100 feet).
4. Weigh or count output from measured drill run.
5. Compare to calculated expected output from step 1 and adjust seed rate.
6. Repeat if necessary.

To calibrate an air delivery system, consult the manufacturer's directions.

FERTILIZER USE

For complete details on soil fertility and fertilizers, consult Manitoba Agriculture and Food's *Soil Fertility Guide*. At least 16 essential plant nutrients are required for growth. An insufficient supply of any or more of these nutrients can have a detrimental effect on plant growth and, ultimately, crop yields. All but three of these nutrients (carbon, hydrogen and oxygen) are derived from the soil. Four nutrients – (nitrogen, phosphorus and to a lesser degree, potassium and sulphur) – are likely to be of concern for Manitoba crop production.

Soil Testing

Soil testing is the only way to determine the available nutrient status of a field and obtain specific fertilizer recommendations. Reliable soil test results and recommendations depend upon:

- proper soil sampling;
- proper soil analysis techniques; and
- sound fertilizer recommendation guidelines.

The following procedures should be followed to ensure representative samples are provided for laboratory analysis.

- all fields should be sampled separately;
- for fields with varying topography, consider sampling and analyzing soil from different topographical areas separately;
- samples should be taken in the spring, or in the preceding fall after soil temperatures drop below 5° C;
- samples should be taken from a large number (12-20) of "average" locations within the field. Non-representative sites should not be included in the composite sample, but sampled separately;
- samples should be taken at 0-6 inch and 6-24 inch depths to get a proper and complete measure of the amounts of nutrients (particularly nitrogen and sulphur) available. All crops usually extract nutrients and water to at least the 24-inch depth over the growing season;
- if samples cannot be delivered directly to the laboratory, they should be air-dried. Alternatively, samples can be frozen immediately until they can be dried;
- samples should be kept clean. Be careful to keep fertilizer dust, ashes, etc. from contaminating the sample. Metal pails should not be used to collect or mix samples if micronutrients are to be analyzed.

For more details on soil sampling refer to Manitoba Agriculture and Food's *Soil Fertility Guide* or your soil test laboratory.

Fertilizer Recommendations

The recommendations printed in this guide are very general. With a soil test specific recommendations can be determined using the Soil Fertility Guide or from the soil test laboratory.

General fertilizer guidelines for producers without a soil test are included in each crop section.

For information on inoculation of pulse crops see page 48. For information on inoculation of forage crops see page 78.

Nitrogen

Nitrogen recommendations are based upon the estimated crop requirements and residual soil nitrogen levels. Fields that are summerfallowed, have been heavily manured, follow a forage legume, are repeatedly fertilized with high rates of nitrogen and/or affected by drought may contain sufficient nitrogen for the crop.

Summerfallow is not a recommended practice in Manitoba, since it has a detrimental effect on soil quality and leaves the soil susceptible to erosion. However, in emergency situations where fallowing has been done, these fields may contain considerable nitrogen for crop production.

Likewise, soils following legume breaking (breaking after first cut of forage) will have considerable nitrogen content, which may satisfy all the nitrogen requirements of the following crop (see specific crop general recommendations). Grass and grass-legume breaking provides a lower, but substantial level of nitrogen for following crops. Time and method of legume forage crop removal will determine the relative amounts of nitrogen available. Stands removed before July 1 may meet all the following crop's needs, whereas nitrogen rates should be reduced by 50-75 per cent when stands are removed before September or 30-50 per cent when stands are removed late in the fall or early in the spring. Stands removed by herbicide (without tillage) will make nitrogen available at a somewhat slower rate than if tillage were used. For the subsequent crop, use the lower value of the above ranges if herbicides alone were used.

Nitrogen fertilizers are required when there is insufficient residual soil nitrogen.

The relative efficiency of nitrogen fertilizers is affected by time of application and the method of placement (see Table 2).

Table 2. Nitrogen application time and relative value.

Time and method	Relative values
Spring, broadcast	100
Spring, banded	120
Fall, broadcast	80
Fall, banded	100

Average values of time and methods of placement are relative to spring broadcast nitrogen with a value of 100. These efficiency values were calculated based on nitrogen uptake by plants.

These relative efficiencies should be considered when deciding on nitrogen application rates. Manitoba Agriculture and Food nitrogen recommendations are based on a spring broadcast method of application. Producers using other methods and/or timing may want to adjust nitrogen rates as follows:

$$\text{Adjusted rate} = \frac{\text{Recommended rate} \times 100}{\text{relative value from Table 2}}$$

Relative efficiencies vary greatly with factors such as soil moisture, soil temperature, soil type and weed growth. Risk of nitrogen losses due to leaching, gaseous loss, immobilization and weed growth tends to be higher for fall applied than spring applied nitrogen. Under dry soil conditions, the efficiency of late fall-banded nitrogen will approach that of spring banding. However, fall-banded efficiencies can be less than that indicated in the table under situations of excessive spring or fall moisture and/or early fall application before soils have cooled below 5° C.

Broadcast values assume that urea-based fertilizers are incorporated, where necessary, to minimize ammonia volatilization losses. This is particularly important on soils with high pH or soils that contain free lime at the surface.

Banded refers to any in-soil band application, including with-the-seed banding, provided that seed placed rates do not exceed the safe limit at which damage is caused to the germination and seedling emergence.

In a practical sense, times and methods of application should be based not only on the needs of the crop and the potential losses from the soil but on coordinating the soil fertility program with the overall management of the farm. Select a time and method of N application that permits preparation of a good seed bed, conserves soil moisture, aids in prevention of soil erosion and allows for timeliness of operations.

Nitrogen Fertilizer Placement with the Seed

Placing fertilizer with cereal seed optimizes efficiency. However excessive rates of nitrogen fertilizer may lead to reduced germination and seedling damage due to ammonia toxicity or salt burn. Table 3 contains guidelines

Table 3. Rates of urea nitrogen (lb N/acre) safely applied with cereal and canola seed if seed bed soil moisture is good to excellent.

Soil texture	1 inch spread[1] (disc or knife)[2]			2 inch spread[1] (spoon or hoe)			3 inch spread[1] (sweep)		
	Row spacing								
	6"	9"	12"	6"	9"	12"	6"	9"	12"
	SBU[3]								
	17%	11%	8%	33%	22%	17%	50%	33%	25%
CEREAL SEED									
Light (sandy loam)	10	0	0	20	15	10	30	20	15
Medium (loam to clay loam)	20	15	10	30	25	20	40	30	25
Heavy (clay to heavy clay)	25	20	10	40	30	25	50	40	30
CANOLA SEED									
Light (sandy loam)	0	0	0	10	0	0	20	10	0
Medium (loam to clay loam)	0	0	0	20	10	0	30	20	10
Heavy (clay to heavy clay)	10	0	0	30	20	10	40	30	20

[1] Width of spread varies with air flow, soil type, moisture level, amount of surface crop residue and other soil conditions, so it must be checked under field conditions.

[2] Some openers give less than one inch spread. Urea should not be applied with the seed on light soils when a double disc opener is being used.

[3] SBU (seed bed utilization) is the amount of the seed bed over which the fertilizer has been spread. Thus, it is a reflection of the relative concentration of fertilizer.

$$\text{SBU (\%)} = \frac{\text{width of spread (inches)}}{\text{row spacing (inches)}} \times 100$$

For example, if the seeding implement has a 6 inch spacing and spreads the seed and fertilizer over two inches, the SBU would be 33 per cent (2/6 x 100 = 33). The higher the SBU, the more fertilizer that can be safely spread with the seed. Although some openers spread the seed and fertilizer vertically, SBU does not take this into account since it is generally recognized that all seed be placed at an even depth for even germination and emergence.

for safe rates of nitrogen placed with the seed of cereals and canola. For more details refer to Manitoba Agriculture and Food fact sheet *Guidelines for Safely Applying Fertilizer with Seed*. Factors affecting safe nitrogen rates include crop type, row spacing, seed and fertilizer spread, soil texture, nitrogen source and soil moisture.

For canola, ammonium nitrate and ammonium sulphate are just as damaging to the seedlings as urea. For cereals only, suggested nitrogen rates can be safely increased by about 20 lb/ac when ammonium nitrate is used.

Where seed bed moisture is low or when weather is hot and windy, reduce the rates in the tables by approximately 50 per cent.

Special notes for anhydrous ammonia

Seeding can be done immediately after anhydrous ammonia application, provided there is at least a 4 inch vertical separation of the injection point and the seed. Crop emergence may be slightly reduced directly over the anhydrous bands, particularly for small seeded crops, and if soils are sandy or dry. However, plants will tiller or branch and yield will not be affected. The ammonia bands should be perpendicular to the direction of seeding.

Anhydrous ammonia cannot be placed with seed. However, in recent years, equipment has been modified to allow anhydrous ammonia to be applied at seeding time in a band or other arrangement that is separated from the seed. The anhydrous ammonia should be separated from the seed by at least 2-3 inches and be placed below and to the side of the seed or to the side of the seed. It should not be applied directly below or above the seed. The anhydrous ammonia tends to follow the furrow upward, so attempts at placing it below the seed will likely lead to seed damage.

For additional information, see Manitoba Agriculture and Food fact sheet *Applying anhydrous ammonia in spring*.

Phosphorus

Most Manitoba soils are phosphorus deficient and crops respond to phosphorus fertilizer application.

Phosphorus efficiency is greatest when applied with the seed, providing the amount does not injure the germinating seedling. Some crops are sensitive to seed-placed phosphorus, whereas cereals can tolerate their total fertilizer phosphorus requirement placed with the seed (Table 4). Monoammonium phosphate (12-51-0, 11-52-0) has a low salt index and does not release much ammonium, so it has relatively low toxicity to seedlings.

Table 4. Maximum safe rates of seed-placed phosphate (P_2O_5) fertilizer as monoammonium phosphate[1].

Crop	Actual P_2O_5 (lb/ac)[2]
Cereals	50
Canola[3], peas[3], field beans, fababeans, buckwheat	20
Flax, black beans	0

[1] *Divide values in table by 0.5 to get lb of product to be applied.*

[2] *Rates are based on disc or knife openers with a 1 inch spread, a 6-7 inch row spacing and good to excellent soil moisture.*

[3] *When phosphorus soil test values are medium to high, no phosphorus should be placed with canola or pea seed.*

Phosphorus fertilizer banded near the seed (beside and /or below) results in the greatest yield increase per unit of phosphorus when recommended rates exceed that tolerated with seed-placed application. Such side banded applications are recommended for most oilseeds, annual legumes and row crops.

Deep banding phosphorus at the 4-6 inch soil depth and in spacings of 12 inches or less before seeding is more effective in increasing yields than broadcast and incorporation methods. Banding nitrogen with the phosphorus may increase phosphorus fertilizer availability.

Broadcast and incorporated phosphorus results in the lowest yield increase per unit of phosphorus. Broadcast application of phosphorus may be uneconomical on many soils, since the amount required in the first few years is two to four times that of seed-placed phosphorus to achieve similar yield increase.

Jump Start® is a microbial seed inoculant registered for use on wheat, canola, peas and lentils. Jump Start may increase the availability of fertilizer phosphorus and soil phosphorus to crops during the growing season by up to 10 lb/acre of phosphate. However, Jump Start does not add phosphate to the soil.

For more information, see Manitoba Agriculture and Food fact sheets *Phosphorus Fertilization in Crop Production* and *Phosphorus Application for Annual Crops*.

Potassium

Most Manitoba soils contain sufficient potassium for crop production. Soils likely to be low in potassium are coarse textured sands, sandy loams and organic soils. Where required, applied potassium can increase crop yield and quality. Depending on the type of crop, it may also increase frost and disease resistance, winter survival, palatability, storage quality and other characteristics.

For most efficient use by cereal crops, potassium should be placed with the seed. For most row crops, potassium should be side banded to the side and/or below the seed. The efficiency of broadcast and incorporated potassium is about 50 per cent that of potassium banded with the seed or side banded. If potassium is broadcast, the recommended rate for seed placement or side banding should be doubled to obtain equal crop response.

For additional information, see Manitoba Agriculture and Food fact sheet *Potassium Fertilization in Crop Production*.

Sulphur

Low levels of sulphate sulphur may be found in any non-saline soil in Manitoba, but occur most frequently on well-drained and grey luvisol (wooded) soils. Soil testing should be done to a 24 inch depth to account for sulphate not at the surface, but still available for crop use.

Sulphate levels within a field can vary, depending upon soil type and slope position. On rolling land, sample hilltops, mid-slope positions and low-lying areas separately. Sandy, coarse textured soils should be sampled separately from heavier soils. This is important since it is not uncommon for low-lying, heavy soils to contain many times more sulphate sulphur than light textured hilltops. Sampling a field such as this as a whole would typically result in a recommendation that no sulphur is needed, yet crops in some areas may be highly sulphur

deficient. For this reason an "insurance application" of sulphur fertilizer may be advisable on variable soils or where high-value, high sulphur-demanding crops are to be grown.

Sulphate forms of sulphur fertilizer are equally effective when applied as a surface application, banded or incorporated. Elemental sulphur must be oxidized by soil micro-organisms to form sulphate before it is used by plants. Elemental sulphur should be applied at least one year before it is needed by the crop and left on the surface as long as possible before incorporation, as rainfall and weathering help disperse the fertilizer granules and speed the conversion to the sulphate form.

For more information, see the Manitoba Agriculture and Food fact sheet *Meeting Sulphur Fertilizer Needs in Manitoba*.

Micronutrients

Most soils are adequately supplied with micronutrients, such as boron, copper, cobalt, iron, manganese, molybdenum and zinc. Micronutrients are likely to limit yields only under very specific soil and crop situations. Diagnose micronutrient deficiencies using the following procedures:

- eliminate other possible causes of poor growth (drought, flooding, shortages of nitrogen, phosphorus, potassium or sulphur);
- determine if a particular soil or crop is likely to be deficient in a micronutrient;
- look for visual deficiency symptoms;
- soil test for micronutrients;
- tissue test for micronutrients;
- apply test strips and observe responses.

Copper and zinc are the two micronutrients most likely to be deficient in Manitoba soils. Copper levels may be low in peat and very coarse textured (sandy), well-drained soils. Crops most sensitive to copper deficiency are wheat, flax, barley and alfalfa. Zinc levels may be low in highly calcareous (high lime content) soils, and the most sensitive crops are corn, field beans and flax.

Crop fertilization with chloride has given inconsistent responses in Manitoba research trials. In a few cases, slight reductions in disease severity and small improvements in yield and grain quality were observed. However, the predictability of a profitable yield response to chloride has been inconsistent for Manitoba crops and conditions. An inexpensive source of chloride is potash (KCl).

Soil testing, tissue sampling and visual deficiency symptoms are used to diagnose micronutrient deficiencies.

Although banding is the most effective method of macronutrient application, thorough mixing with the surface soil is the best method for micronutrient fertilizers. Chelated micronutrients are not influenced by placement so they may be banded without greatly reducing their efficiency. Some micronutrient fertilizers may be toxic when banded with the seed of crops. Refer to manufacturer's recommendations for rates and placement.

If deficiencies are diagnosed in the growing crop, some foliar micronutrient applications may be made. Refer to manufacturer's recommendations for rates and materials.

For more information, see Manitoba Agriculture and Food fact sheets *Micronutrients in Crop Production* and *Copper Fertilizer Requirements on Peat Soils*.

Plant Tissue Analysis

Plant tissue analysis is useful in evaluating fertilizer management practices, diagnosing nutrient related problems and identifying nutrient levels in crops that may limit yield, including micronutrients. Like soil testing, the validity and usefulness of plant tissue analysis depend on proper plant sampling and sample handling procedures. These include:

- Sample crops from individual fields separately;
- Sample the proper plant part at the proper growth stage. This is specific to individual crops. Refer to sampling guidelines from a reliable laboratory.
- Sample an adequate number of representative plants from a large number of "average" locations in a field. Abnormal plants from non-representative field locations should not be included unless the "comparative sampling approach" is used. Here samples are taken separately from normal and abnormal areas to determine if plant nutrition is the cause of the difference.
- Dry samples as soon as possible after sampling, at room temperatures not exceeding 35° C;
- Avoid contamination of sample with fertilizer dust, cigarette ashes and other substances.

Organic Soils

Crops such as barley, oats, Polish canola and grasses perform better on organic soils than wheat and flax, due to the cooler micro-climate.

Most organic soils are very deficient in phosphorus and potassium. Producers on organic soils should use the higher rates of phosphate and potassium recommended in this publication for each crop.

Organic soils are frequently deficient in copper and may also be deficient in manganese and boron. Copper deficiencies are more likely in deep organic soils (at least 24 inches in depth) and manganese deficiencies on the shallower organic soils (less than 14 inches) that are over a high lime mineral subsoil. Use both soil and plant analyses as aids in determining if these micronutrients are deficient. Conduct small-scale trials - apply micronutrients to portions of a field to assess the effects of micronutrient fertilizers on crop yields before applying over large areas.

Additional information is available in Manitoba Agriculture and Food fact sheets: *Introduction to Peat Soil Management, Managing Crops on Peat Soils, Nitrogen Management for Crop Production on Peat Soils* and *Copper Fertilizer Requirements on Peat Soils.*

Calculation of Fertilizer Rates

Fertilizers are labelled by percentage according to their guaranteed minimum analysis in terms of nitrogen (N), phosphate (P_2O_5) and potash (K_2O). For example, 16-20-0 (14) contains 16 per cent nitrogen by weight, 20 per cent phosphate by weight, 0 per cent potash by weight, and 14 per cent sulphur by weight. The actual weight of nutrients in 100 lb fertilizer is: N = 16 lb, P_2O_5 = 20 lb, K_2O = 0.5 lb and S = 14 lb.

Table 5. Common fertilizers.

Fertilizer	Liquids (solutions)
Ammonium phosphate	10-34-0
Nitrogen solution	28-0-0
Aqua ammonia	20-0-0
Ammonium thiosulphate	12-0-0 (26)[1]
Ammonium thiosulphate and nitrogen solution	15-0-0 (20)
Phosphoric Acid	0-52-0
	Gas (compressed)
Anhydrous ammonia	82-0-0
	Dry (solids)
Ammonium phosphate	10-50-0 to 11-55-0
Ammonium phosphate sulphate	16-20-0 (14), 17-20-0 (15)
Diammonium phosphate	18-46-0
Ammonium nitrate phosphate	24-22-0, 28-13-0
Urea ammonium phosphate	27-27-0, 34-17-0
Ammonium sulphate	21-0-0 (24), 20-0-0 (24), 19-3-0 (22)
Ammonium nitrate phosphate sulphate	26-13-0 (3)
Ammonium nitrate	34-0-0
Urea-ammonium sulphate	34-0-0 (11)
Urea	46-0-0
Potassium chloride	0-0-60, 0-0-62
Potassium sulphate	0-0-50 (18)
Sulphur (elemental)	0-0-0 (90)

[1] *The number in brackets denotes the approximate percentage of sulphur in the fertilizer.*

In addition to these premixed fertilizers, micronutrients and specially blended fertilizers (including suspension) are available from some fertilizer dealers.

For example:

1. Using 34-0-0

   Rate of N desired = 40 lb/acre

   Rate of fertilizer required =

   $$\frac{40 \times 100}{34} = 117 \text{ lb/acre}$$

2. Using 16-20-0 (14)

   Rate of P_2O_5 desired = 20 lb/acre

   Rate of fertilizer =

   $$\frac{20 \times 100}{20} = 100 \text{ lb/acre}$$

   100 lb/acre of 16-20-0 (14) would also supply nitrogen at the rate of:

   $$\frac{16 \times 100}{100} = 16 \text{ lb/acre}$$

   and sulphur at the rate of:

   $$\frac{14 \times 100}{100} = 14 \text{ lb/acre}$$

Additional information is contained in Manitoba Agriculture and Food fact sheet *Calculating Nutrient Costs* and *Fertilizer Rates*.

Manure

Manure can provide organic matter and an appreciable part of the nutrients required for production of crops. Do not apply more nutrients than the crop needs.

Nutrient composition of manure will vary from source to source. A manure analysis is a much more accurate method of determining the nutrient value and determining application rates than using average manure nutrient values (see Table 6 below). Nutrient content of liquid manure often varies in proportion to the solids content of the manure.

Only about half of the total nitrogen in manure is available to the crop. The portion in the organic form becomes slowly available over a number of years. Likewise, only about 40-50 per cent of total phosphorus is available as the remainder in the organic form is slowly available. Placement of manure in an injected band may maximize phosphorus value. Most potassium in manure is immediately available for crop use.

Table 6. Average nutrient analysis of manures and the amount available for crop use the year applied.

Type of manure	Number of samples	Total N (avail)*	Ammonium N	Organic N	Phosphate P_2O_5 (avail)*	Potassium K_2O	Sulphur S	Dry matter content %
LIQUID		lb/1000 gallons						
Hog	36	23 (18)	16	7	15 (7.5)	13	1.4	2
Dairy	7	26 (18)	14	12	13 (6.5)	29	2.4	6
SOLID		lb/ton						
Hog	3	14 (6)	2	12	15 (7.5)	16	2.5	35
Poultry	2	34 (12)	2.3	32	30 (15)	28	6.5	57
Beef	33	9 (3)	0.3	9	4 (2)	11	1.4	30

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*amount available for following crop use; for nitrogen = ammonium-N + 30% of organic-N, for phosphorus = 50% of total phosphate.

Most of the readily available nitrogen is in the ammonia form. Utilization by the crop is dependent upon application method and time of spreading. Nitrogen losses are minimal when manure is injected or broadcast and immediately incorporated. Losses may exceed 60-80 per cent if surface-applied and incorporation is delayed more than 3 days.

Manure applied at rates that exceed the ability of the crop to use the nitrogen may contribute to nitrate leaching below the crop rooting zone. As a result, Manitoba has developed guidelines for acceptable manure application rates, based upon animal type, number of animals, manure storage and application factors, soil and crop nitrogen utilization factors and the days of manure production.

Refer to *Farm Practices Guidelines for Hog Producers in Manitoba, Farm Practices Guidelines for Beef Producers in Manitoba, Farm Practices Guidelines for Dairy Producers in Manitoba* or *Farm Practices Guidelines for Poultry Producers in Manitoba*.

Based on these guidelines and annual applications, following are the maximum manure nitrogen applications permitted on various crops and soils (see Table 7).

Table 7. Maximum annual manure application guidelines.

Type of crop	Nitrogen lb/acre
Forages, established stands:	
Alfalfa	225
Grasses	150
Grass-alfalfa mixture	175
Annual crops:	
medium to heavy soils	80
light soils	60

There is no economic return to applying manure to alfalfa because it can use nitrogen "fixed" from the atmosphere. However, alfalfa is a heavy user of nitrogen and will preferentially use soil nitrogen or nitrogen applied as manure. Alfalfa may be an excellent crop on which to apply manure if no other crop land is available.

Higher allowable application limits are permitted on heavier soils than on well-drained sands, because crop yield potential and nitrogen requirements are greater and risk of groundwater pollution by leaching is less.

GRAIN DRYING AND STORAGE OF DAMP GRAIN

Aeration

Aeration is the use of relatively low airflow rates to cool grain and eliminate temperature and moisture differences in the storage bin. Aeration may be used with field-dried grain or with grain that is harvested damp, then dried and cooled in a heated air dryer. In both cases, temperature and moisture content variations may exist in the grain, or the grain may be too warm to store safely. Variations in grain temperature are also caused by changes in the outside air temperature after the grain is stored.

Warm air rising in the centre of the bin cools when it reaches the cold grain near the surface. This results in an increase in moisture content near the surface, which can lead to rapid spoilage. Crusting on the surface of stored grain is a common symptom of moisture migration. Significant migration can occur in cereal grains at moisture contents as low as 12 per cent, or as low as 8 per cent in oilseeds if they are placed into storage at high temperature and not cooled.

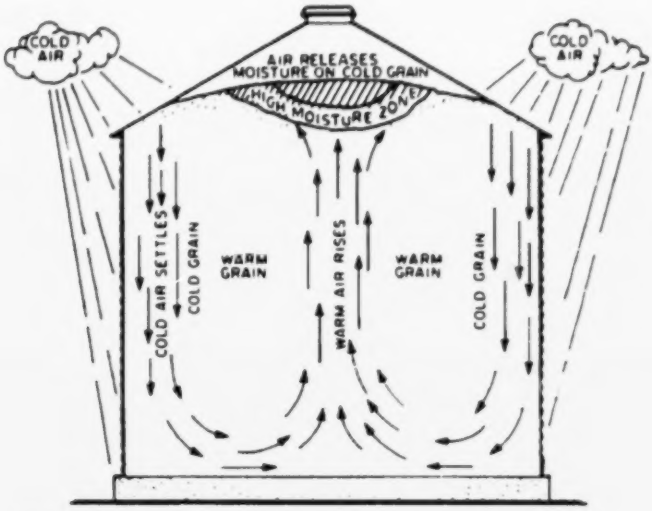


Figure 1. Moisture migration in stored grain – fall and winter

Satisfactory performance of an air handling system depends on the selection of proper equipment, adequate sizing, proper installation and good management (Table 8). Three requirements must be met to ensure proper performance:

1) Selection of a fan or combination of fans that deliver the required air flow at the necessary static pressure.
2) Proper sizing and arrangement of the perforated duct surface area or perforated floor area to deliver the air uniformly.
3) Proper sizing (cross-sectional flow area) of the ducts, fan transition and bin exhaust vents.

The entire design procedure is available in a computer program that calculates the airflow and static pressure requirements for various grains, airflow rates, bin diameters and grain depths. It will also select suitable fans by make and model. The program can predict airflow rates for any given fan, bin and grain combination, and simulate drying for wheat, barley and canola. The computer program can be accessed at any of the following agricultural engineering offices of Manitoba Agriculture and Food.

Dauphin - 622-2020

Brandon - 726-6408

Portage la Prairie - 239-3364

Beausejour - 268-6011

Table 8. Summary of basic recommendations for drying and cooling processes in stored grain.

Process	% above "dry"*	Recommended airflow rates (L/s) m^3	Recommended Minimum Perforated Floor Area (%)	Transfer for final storage
Aeration	0	1-2	15%	no
Unheated Air Drying	1-6	5-30**	100	no
Dryeration	2-3	5-10	40	yes
			100	no
In-Storage Cooling	1	5-10	40	no

* % above "dry" is the number of moisture percentage points above "dry" at which the grain is placed into the bin. Example: For dryeration, wheat is placed into the bin at up to 17 per cent moisture (14.5 + 2.5 = 17 per cent)

** Recommended minimum airflow rate for drying grain depends on grain moisture content and harvest date.

Heated-Air Grain Dryers

Advantages of Grain Drying:

Longer Harvest Season - A grain dryer can substantially increase the number of available harvesting hours and days in most areas, and could also reduce the overall investment in machinery. A smaller combine plus a dryer could be used instead of buying a second combine or trading up to a larger one. For a producer relying on custom harvesting, a grain dryer can be helpful in getting harvesting done early.

Earlier Harvesting - Earlier harvesting is possible when a grain dryer is used. Wheat, oats and barley can be threshed at 20 per cent moisture content (MC) and then dried without loss of quality, grade or germination. When compared with harvesting at 14 per cent, there may be a difference of only one or two days in mid-August, but by mid-September it may be 4 days or more. If a wet spell occurs, the differences could be much greater. Early harvesting may allow a producer to harvest nearer to the maximum 'dry' moisture content, which results in the highest weight of grain for sale. Harvesting early also allows a producer to do a better job of weed control through timely chemical application and tillage practices.

Reduced Field Losses - Weather damage and losses caused by wildlife can be reduced by harvesting at the tough or damp stages. Losses in grade and weight due to weather can be substantial. Harvesting before, instead of after, a rainy spell can therefore result in a considerable saving. Straight combining of some crops, such as sunflowers and corn, is a necessity, and if these crops are harvested damp, field losses are greatly reduced. A dryer in the system may also make it feasible to straight combine other crops. Overdrying of crops in the field, which leads to shattering and crop loss, can also be prevented by earlier harvesting. A dryer is therefore an alternative that could be considered to reduce field losses.

Eliminate Spoilage in Storage - When tough or damp grain is harvested and not dried, long-term storage frequently results in grain spoilage. Moisture migration within grain bins can make slightly tough or even dry grain unsuitable for storage. Spoilage problems caused by hot spots and insect infestations can be reduced or eliminated by proper drying and aeration in storage.

Economics - The initial cost of a dryer is one of the major deterrents to grain drying. Where only small amounts of grain are to be dried each year, the initial cost should be a primary consideration. Where large amounts of grain are dried, fuel efficiency becomes the most important factor.

The labor and inconvenience of drying are also deterrents on many farms where no centralized grain storage facility exists. To obtain maximum benefits from a grain dryer, it is necessary to set up a well-organized system for grain handling and storage.

Testing for Heat Damage - Various tests may be conducted to find the highest acceptable drying temperatures for a particular grain and dryer. If the grain is to be used for seed, a germination test should be used. In addition, a sample of grain should be taken before drying for testing to help determine whether there was any change in the germination rate during the drying process. Commercial grains other than for seed (milling wheat, malting barley and oilseeds)

are tested **free of charge** for heat damage by the Canadian Grain Commission. Two samples (minimum of 500 g each), one taken before and one after drying, should be sent to the Grain Research Laboratory, Canadian Grain Commission, 303 Main Street, Winnipeg, Manitoba, R3C 3G8. The samples should be representative of the grain going in and coming out of the dryer. If the grain quality is unchanged, a higher temperature can be tried and two more samples sent in for testing. Several companies that purchase oilseeds, corn and grain for seed also conduct tests for heat damage. Check with the purchaser at the start of drying to ensure that the dried grain meets their standards.

For more information refer to Manitoba Agriculture and Food fact sheet *Grain Aeration and Unheated Air Drying* and Agriculture Canada's fact sheet *Heated-Air Grain Dryers*.

Storage Moulds

Storage moulds are types of fungi that grow in stored grain at temperatures as low as -5°C and moisture contents at/or above those given in Table 8. Detrimental changes in grain appearance and quality occur in storage. Byproducts of most storage moulds are mycotoxins, such as ochratoxin, which are poisonous to humans and animals. Infections by storage fungi are promoted by high temperatures, seed injury, green crop or weed debris and especially moisture. Grain in storage should be monitored periodically for evidence of heating and off-odours which are indications of mould growth.

PREVENTION AND CONTROL OF INSECTS AND MITES IN FARM-STORED GRAIN

Identification

The main pests of farm-stored grain include both grain-feeding and fungus-feeding species.

Grain-Feeding Pests - Insects that feed on the grain include rusty grain beetle, red flour beetle, saw-toothed grain beetle and larvae of the Indian meal moth. The rusty grain beetle is the most common stored-products insect in Manitoba. The adult is a flat, rectangular, reddish-brown beetle, less than 1/8 inch (2 mm) long, with long threadlike antennae. Heavy infestations of this insect cause grain to heat and spoil. The red flour beetle is the second most common insect pest of stored grain in Manitoba. Adults are reddish-brown and 3/8 inch (4 mm) long. Adult saw-toothed grain beetles are brown, about 1/8 inch (3 mm) long, and have six tooth-like projections on each side of the thorax. Saw-toothed grain beetles are more common in stored oats than in stored wheat and barley. Indian meal moth larvae construct tunnels of silk and droppings through stored grains, as well as feeding on the grain. They have been found on stored corn in Manitoba.

Fungus-Feeding Pests - Pests that feed on fungus in stored grain include the foreign grain beetle, psocids and grain mites. Adult foreign grain beetles are brown, and about 1/8 inch (2 mm) long. They resemble the rusty grain beetle, but can be distinguished from it by club-shaped antennae. Grain mites are whitish, soft-bodied and about 0.2 to 0.5 mm long. They are difficult to see with the naked eye. About eight kinds of mites are common in farm granaries and elevators. Psocids are soft-bodied insects, about 1 mm long, with long antennae relative to the body size.

Figure 2. Grain-feeding Pests

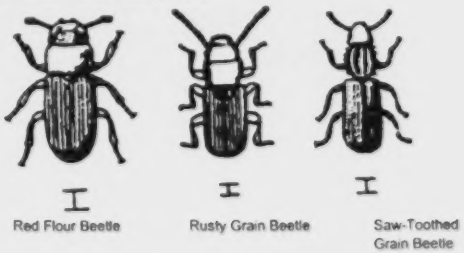
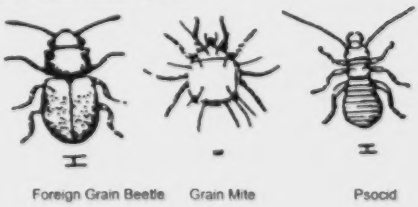


Figure 3. Fungus-feeding Pests



Preventing Pest Infestations

- Clean up and burn or bury any grain spilled when bins are filled or emptied. Spillage is an excellent breeding site for grain insects.
- Destroy residues after grain has been removed from piles or temporary storages.
- Initiate a granary clean-up program that includes:
  - repairs and weatherproofing
  - cleaning and burning or burying sweepings to prevent insect breeding
  - thoroughly spraying the granary with a mixture of 1/2 pt (60 ml) malathion 50% EC in 1 gal (4 L) water. Apply the mixture at a rate of only 1 gal/1,000 sq ft (5 L/100 m^2) or to the point of runoff.
- Frequently examine stored grain for signs of crusting or spoiling and break any crusted areas.
- Place metal rods into the core of bulk stored grain and inspect every 3 to 4 weeks for signs of heating.

Monitoring Pest Levels

Stored grain insects can be monitored either with traps, or by taking grain samples with a bin probe and then visually inspecting the samples. Traps for stored grain insects are long cigar-shaped tubes that are stuck into the top of the grain sample. For some traps there are pheromone attractants available, which may improve trapping efficiency. Regular inspection with traps or probe samples will indicate potential problems that may be developing in the bin.

Control of Fungus-Feeding Pests

Be sure the grain is in good storage condition by:

- removing crusted areas and hot spots
- burning or burying discarded grain
- drying grain, if necessary

Chemical control of fungus-feeding pests is not necessary, since they cannot survive in sound, dry grain.

Control of Grain-Feeding Insects

Grain-feeding insects are treated differently from fungus-feeding insects. An effective method of controlling insect infestations in stored grain in winter is to lower the temperature of the grain. Rusty grain beetles and most other stored grain insects can be killed by periods of low temperatures as follows:

Grain Temperature	Time Required to kill insects
-5° C	6 weeks
-10° C	4 weeks
-15° C	2 weeks

The use of pneumatic conveyors to move grain has been shown to give good control of some insect pests of stored grain. Chemical treatment of the bin is another option. Fumigants containing phosphine gas are available under several trade names in pellet or tablet form. Solid fumigants should be used only when the grain temperature is above 4°C. As an alternative to fumigants, diatomaceous earth can be used for control of grain feeding insects in many stored grains.

BARLEY

Field Selection

Select fields with good drainage, sandy loam to heavy clay soil textures.

For malting, seed or food uses, avoid fields where volunteers of other varieties of barley, other cereals and large oilseeds such as sunflowers may be a problem. Avoid fields that had cereal crops in the previous year to reduce disease pressure and optimize yields.

Seeding

Treatments

Loose or surface-borne smuts (covered and false loose smut) that attack barley can be controlled by fungicide seed treatment. Leaf spot diseases of barley overwinter on barley straw, stubble and seed. Treat seed from infected fields to reduce seedling infection.

Dates

May 1 to May 31. On average, the best quality and the highest yields are obtained from barley that is sown early.

Rates

1.25 to 2.25 bu/acre to achieve a plant population of 22-25 plants/ft^2. See page 7 for calculating optimum seeding rates using plant population. Circumstances requiring heavier seeding rates include large seed size, low germination, late seeding, abundant moisture, deep seeding, rough seed bed and high weed pressure.

Depth

1.5 to 2 inches. Deeper seeding results in weaker plants, reduced emergence, greater susceptibility to root rot and decreased yield.

Fertilizer

General

For specific recommendations, have your soil tested. If soil analyses are not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-55 lb/acre N following grass and grass-legume breaking and 55-90 lb/acre N following stubble. The primary nitrogen deficiency symptom is leaf yellowing starting with the older leaves. If nitrogen deficiencies are visible in the field, loss in yield potential has already occurred.

Phosphate (P_2O_5): Apply phosphate rates at 30-40 lb/acre.

Potassium (K_2O): On sandy-textured or organic soils, apply potassium rates of 15-30 lb/acre.

Sulphur (S): Low sulphur levels can occur in any Manitoba soils. When required, apply 15 lb/acre of sulphate sulphur. The primary sulphur deficiency symptom is leaf yellowing, starting with the newest leaves.

Special Considerations:

For a recommended malting barley variety to be acceptable for a malting grade, the grain should contain 10.5 to 13 per cent protein. Protein levels in barley are determined by the amount of available nitrogen plus growing season moisture and temperature conditions. High rates of nitrogen and/or limited growing-season moisture may result in protein content above the acceptable levels.

Weeds

Barley is a competitive crop that has the ability to choke out many weeds. Depending on the relative time of emergence and the weed density, herbicides may not be necessary, which improves net returns.

Insects

Grasshoppers, aphids, cutworms, wireworms and armyworms can damage barley. A dual-purpose seed treatment that includes an insecticide should be used if wireworms are expected to be a problem.

Diseases

Barley fields should be monitored for leaf diseases on a regular basis during the growing season. Identify the disease and, if control is warranted, apply a registered fungicide to minimize yield loss. Timing of the fungicide application is critical, so read and follow label directions carefully.

Net blotch and **scald** are the most common foliar diseases attacking most varieties of barley. Fields where these or other troublesome barley diseases are found should not be planted back to barley the next year because of an increased risk of a serious yield loss and reduced kernel plumpness.

All forms of **smuts** can be controlled with the appropriate seed treatment.

If **ergot** has been a problem, rotate with a non-susceptible crop for one year to reduce disease incidence. Cultivate fields after harvest to bury ergot bodies to a depth of at least two inches. Mow grass headlands and roadsides before heading to reduce ergot spread. If the seed source is known to contain ergot bodies, storage for more than one year reduces the viability to almost zero. Levels of ergot bodies in the harvested grain above 0.1 per cent may be toxic in livestock feed.

Harvesting

Swathing

Swath when the heads have lost their green colour and have a moisture content below 30 per cent. At 30 per cent the barley kernel is firm but can be dented with your thumbnail.

Combining

Hulled Barley

To minimize cracking and breakage, slow the cylinder speed, increase the concave clearance and maintain low volume in the return. For malting barley, check the sample for the presence of a bit of awn on the kernels to signal that the combine is doing a proper job of threshing. Awns of 1/8 to 1/4 inch left on the kernels are desired.

Combining can begin at 18 per cent to 20 per cent if the grain is to be dried. Higher kernel moisture content may lead to storage problems. For malting barley, combining and handling below 13.5 per cent may cause peeling. Natural air drying systems can be used to allow harvesting by straight combining or picking up swaths to begin at 16 per cent moisture. Threshing malting or seed barley at a moisture content greater than 16 per cent, then aerating, has led to disappointing results due to germination loss during storage.

Hulless Barley
For hulless barley, examine the threshed grain for cracking or the presence of adhering hulls above the grading limits (5 per cent limit for human consumption, 15 per cent limit for feed). A dehulling process may be required to reduce the percentage of hulls adhering to meet grade requirements.

Hullness barley should not be combined above 13.5 per cent kernel moisture as it will be difficult to remove the hulls.

Storage

Malting barley at 13.5 per cent moisture is desirable. Over 14.0 per cent moisture does not store well and the quality and germination capacity may deteriorate. Ideal storage conditions can be maintained by means of natural aeration or frequent turning of the grain in the bin.

Feed barley should be stored at 14.5 per cent or less kernel moisture.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

OATS

Field Selection

Select fields with good drainage, sandy loam to heavy clay soil textures. Avoid fields that had cereal crops in the previous year to reduce disease pressure and optimize yields.

Seeding

Treatments

There are a limited number of seed treatments available. To prevent smut, seed should be treated with a fungicide. Seed treatment is recommended for hulless oats.

Dates

May 1 to June 10. Oats give best returns when sown early.

Rates

1.5 to 3 bu/acre to achieve a plant population of 18-23 plants/ft^2. See page 7 for calculating optimum seeding rates using plant population. Circumstances requiring heavier rates of seeding are large seed size, low germination, late seeding, presence of wireworms, abundant moisture reserves, heavy-textured soils, high soil fertility, deep seeding, low bushel weights and rough seed bed.

Hulless oats have a thin seed coat, which is subject to cracking, resulting in lower germinations. It is important to know the level of germination in order to adjust the seeding rate. The seeding rate of hulless oats is 48-62 lb/acre or to achieve a plant population of 18-23 plants/ft^2.

Depth

1.5 to 3 inches. Seed should be placed only deep enough to reach moisture. Seed placed deeper than three inches may result in reduced emergence and reduced yields.

Fertilizer

General

For specific recommendations, have your soil tested. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-55 lb/acre following grass and grass-legume breaking and 55-90 lb/acre N following stubble. The primary nitrogen deficiency symptom is leaf yellowing starting with the older leaves.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre. The primary phosphorus deficiency symptom is leaf purpling/browning starting at the tips of older leaves on the seedling.

Potassium (K_2O): On sandy-textured or organic soils apply potassium as 15-30 lb/acre potash in a sideband or 30-60 lb/acre broadcast. Where required, potassium should be placed with the seed. Deficiency symptoms are difficult to detect but include short internodes and weak stems.

Sulphur (S): Apply sulphate sulphur at 15 lb/acre on well-drained soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields.

Weeds

Weeds can reduce yields and the quality of the crop. Weed seeds that cannot be cleaned out and are considered foreign matter causing downgrading are: other cereal crops, grains other than cereal crops, wild oats. There are no herbicides available for controlling these weeds in oats. Use proper crop rotations and cultural strategies to ensure oats are planted on fields free of these weeds.

Insects

Aphids, armyworms, cutworms, leafhoppers, grass thrips, wireworm, grasshoppers and the wheat stem maggot can damage oats.

Diseases

Earlier seeding and heavier seed rates will reduce damage by **barley yellow dwarf virus**. The primary symptom of BYD infection in oats is red leaf.

Seed treatments are available for the control of seedling blight and smut diseases carried on the seed. Most varieties have only fair or poor resistance to crown rust (leaf rust) and serious yield losses can occur especially to late-planted oat crops.

Currently recommended oat varieties are resistant to oat stem rust.

Harvesting

Swathing

Highest yields are obtained by swathing when the kernel moisture content is about 35 per cent. The greenest kernels at this stage have just changed from green to cream-coloured. To obtain highest milling grades, green hulls should not form part of the oat sample.

Combining

To obtain highest milling grades, dehulled kernels must be avoided. This may involve slower cylinder speed and wider concave clearances.

Hulless oats are vulnerable to damage. Thresher cylinder speed should be reduced to approximately 900 rpm and the concaves adjusted carefully to prevent damage.

Storage

Oats with a moisture level 12 per cent or less will store properly. If moisture is above 12 per cent, it should be dried and/or bin aerated to prevent heating and mould development.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

RYE

Field Selection

Select fields with good drainage, sandy loam to heavy clay soil textures. Avoid fields that had cereal crops and forages grasses in the previous year to reduce disease pressure and optimize yields.

Seeding

Treatments

To prevent seed and seedling rots/blight and smuts, seed should be treated with a fungicide.

Dates

Fall rye - August 25 to September 25
Spring rye - May 1 to May 30

Rates

0.75 to 1.5 bu/acre to achieve a plant population of 24 plants/ft^2. See page 7 for calculating optimum seeding rates using plant populations. High rates of seeding should be used with large seed size, poor germination, weed competition or poor seed bed conditions.

Depth

1 to 2 inches. Do not plant rye deeper than necessary to ensure contact with moist soil. Deeper seeding may result in decreased emergence and weak plants, causing severe winter kill in fall-seeded varieties.

Fertilizer

General

For specific recommendations, have your soil tested.

If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-20 lb/acre N following fallow or legume breaking, 20-40 lb/acre N following grasses and grass-legume breaking and 40-60 lb/acre N following stubble. Broadcast ammonium nitrate (34-0-0) in the spring, as soon as field conditions allow machinery to travel. Delayed applications result in reduced yield. Broadcasting nitrogen fertilizers such as urea (46-0-0) or urea-ammonium nitrate solution may result in reduced yield due to losses of N through volatilization, especially under warm dry conditions. The primary nitrogen deficiency symptom is leaf yellowing, starting with the older leaves.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre. The primary phosphorus deficiency symptom is leaf purpling/browning, starting at the tips of older leaves on the seedling.

Potassium (K_2O): On sandy-textured or organic soils, apply potassium at rates of 15-30 lb/acre potash in a sideband or 30-60 lb/acre broadcast. Where required, potassium should be placed with the seed. Deficiency symptoms are difficult to detect, but include short internodes and weak stems.

Sulphur (S): Usually not limiting for rye production. Soils low in organic matter may be deficient in sulphur.

Weeds

Rye, particularly fall rye, is a competitive crop that can choke out many weeds. Depending on the relative time of emergence with weeds and the weed density, herbicides may not be necessary, which increases net returns.

Control of winter annual weeds such as stinkweed, shepherd's purse, flixweed and narrow-leaved hawk's beard is particularly important in fall rye. Best control of winter annual weeds with herbicides is achieved in the fall after the weeds have germinated and immediately before freeze-up. They may also be treated the

following spring, but must be sprayed before the weeds bolt, which occurs in late April or early May.

Weeds that cannot be cleaned out of rye and therefore are considered foreign matter causing downgrading are: cow cockle, ragweed, tartary buckwheat, vetch, wild oats, cereal grains and non-cereal domestic grains such as peas, corn, domestic buckwheat, lentils.

Insects

Grasshoppers, aphids, cutworms and armyworms can damage rye.

Diseases

Seed Rot and Seedling Blights

Rye seed should be treated with a suitable fungicide to reduce seed rot, seedling blights and smut.

Ergot

Rotate with a non-susceptible crop for one year to reduce incidence. Cultivate fields following harvest to bury ergot bodies to a depth of at least two inches, and mow grass headlands and roadsides before heading to reduce spread. If the seed source is known to contain ergot bodies, storage for more than one year will reduce their viability to almost zero. Levels of ergot bodies in the harvested grain above 0.1 per cent may be toxic in livestock feed.

Harvesting

Swathing

Fall rye should be swathed at the milk stage (45 per cent moisture content), or shattering may become a problem during swathing and combining. Straight combing is not recommended, since shattering will be a problem and will result in volunteer growth in the succeeding crop.

Combining

Rye kernels with a moisture content of 14 per cent can be safely combined without the need for drying.

Rye threshes very easily. Care should be taken to adjust the concave setting and/or cylinder speed to minimize cracking under dry threshing conditions.

Storage

Moulds and mites tend to be inactive when storage moisture is below 13 per cent. If storage temperatures are below 8° C, 3° C and -8° C, insects, moulds and mites, respectively, are inactive.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds, crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

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TRITICALE

Field Selection

Select fields with good drainage, sandy loam to heavy clay soil textures. Avoid fields that had cereal crops and forage grasses in the previous year to reduce disease pressure and optimize yields.

Seeding

Treatments

There are no seed treatments available.

Dates

April 15 to May 15. Triticale must be sown as early as possible for maximum yields.

Rates

2 to 3 bu/acre depending on seed size to achieve a plant population of 24-30 plants/ft^2. See page 7 for calculating optimum seeding rates using plant populations. Circumstances requiring heavier rates of seeding are large seed size, low germination, abundant moisture, deep seeding, heavy-textured soils, rough seed bed and heavy weed pressure.

Depth

1 to 2 inches. Triticale should not be placed deeper than necessary to ensure contact with moist soil. Decreased emergence and weaker plants may result from deeper seeding.

Fertilizer

General

For specific recommendations, have your soil tested.

If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-20 lb/acre N following fallow or legume breaking, 20-40 lb/acre N following grass and grass-legume breaking, and 40-60 lb/acre N following stubble. A shortage of nitrogen will significantly reduce yield. The primary nitrogen deficiency symptom is leaf yellowing, starting with the older leaves.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre. The primary phosphorus deficiency symptom is leaf purpling/browning, starting at the tips of older leaves on seedlings.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 15-30 lb/acre. Where required, potassium should be placed with the seed. Deficiency symptoms are difficult to detect but include short internodes and weak stems. To confirm suspect deficiencies, conduct a tissue test.

Sulphur (S): Low sulphur levels can occur in any Manitoba soils. When required, apply 15 lb/acre of sulphate sulphur.

Weeds

There are a limited number of herbicides available for weed control.

Weed seeds that cannot be cleaned out, and are considered foreign matter causing downgrading, are: cow cockle, ragweed, tartary buckwheat, vetch and wild oats, non-cereal domestic grains such as peas, corn, domestic buckwheat, lentils and cereal grains.

Insects

Grasshoppers, aphids, armyworms, wheat midge and cutworms can damage triticale.

Diseases

Triticale is slightly more susceptible than wheat is to ergot. If ergot is found in a field, rotate with a non-susceptible crop for one year to reduce incidence. Cultivate fields following harvest to bury ergot bodies at least two inches. Mow grass headlands and roadsides before heading to reduce spread. If the seed source contains ergot bodies, storage for more than one year reduces their viability to almost zero. Ergot body levels in the harvested grain above 0.1 per cent may be toxic in livestock feed.

To reduce risk of incidence of damping off and fusarium, avoid sowing on land that had barley, rye, triticale or wheat the previous year.

Harvesting

Swathing

Triticale is more susceptible to sprouting in the swath than hard red wheat. Straight combing is advisable, since it has been successful in minimizing sprouting damage. If swathing is required, it may be swathed, without loss of yield, bushel weight or quality, when the kernels have 35 per cent moisture or less.

Combining

Combine settings should be similar to wheat. Care should be taken to reduce the number of cracked kernels by slowing the cylinder speed.

Triticale with a moisture content of 14 per cent can be safely combined without the need for drying. Kernels with a moisture content of 20 per cent can be combined and dried without loss of quality.

Storage

Moulds and mites tend to be inactive when storage moisture is below 13 per cent. If storage temperatures are below 8° C, 3° C and -8° C, insects, moulds and mites, respectively, are inactive.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

SPRING WHEAT

Field Selection

Select fields with good drainage, sandy loam to heavy clay soil textures. Avoid fields that had cereal crops in the previous year to reduce disease pressure and optimize yields.

Seeding

Treatments

To prevent seed and seedling rots/blight and common bunt, seed should be treated with a fungicide.

Dates

May 1 to May 31. Begin to seed as early as possible since delays in seeding may result in lower yields, particularly with Canada Prairie Spring Red (CPSR) and Canada Prairie Spring White (CPSW) wheats.

Rates

1 - 2.6 bu/acre to achieve a plant population of 23-28 plants/ft^2. See page 7 for calculating optimum seeding rates using plant populations.

Table 9 lists seeding rates for different wheat classes. CPSR, CPSW, CWES and CWAD are sown at higher rates because of larger seed size, as compared with CWRS, to obtain the same plant stand.

Seeding on the high end of the recommended range reduces the number of tillers and shortens time to maturity. These higher rates should be used when seed size is large, germination is low, seeding is late, abundant moisture, deep seeding, heavy-textured soils, rough seed bed and high weed pressure. Durum wheat should be seeded at the higher rates because of its large seed size.

Depth

1.5 to 3 inches. Seed should be placed only deep enough to reach moisture. Seed placed deeper than three inches may result in reduced emergence, plant vigour and yields.

Table 9. Seeding rates for spring wheat.

TYPE	KERNEL WEIGHT g/1000 kernel	SEEDING RATE lb/ac	SEEDING RATE bu/ac
Canada Western Red Spring (CWRS)	37	84-120	1.4-2
Canada Prairie Spring Red (CPSR) and Canada Prairie Spring White (CPSW)	42	90-135	1.5-2.25
Canada Western Extra Strong (CWES)	42	90-135	1.5-2.25
Canada Western Amber Durum (CWAD)	48	108-156	1.8-2.6

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested.

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-55 lb/acre N following grass and grass-legume breaking and 55-90 lb/acre N following stubble. Wheat requires large amounts of nitrogen, and a shortage of nitrogen will significantly reduce yield and make the crop more susceptible to diseases. The primary nitrogen deficiency symptom is leaf yellowing, starting with the older leaves. If nitrogen deficiencies are visible in the field, loss in yield potential has already occurred.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre. The primary phosphorus deficiency symptom is leaf purpling/browning, starting at the tips of older leaves on seedling wheat.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 15-30 lb/acre. When required, potassium should be placed with the seed. Deficiency symptoms are difficult to detect, but include short internodes and weak stems.

Sulphur (S): Low sulphur levels can occur in any Manitoba soils. When required, apply 15 lb/acre of sulphate sulphur. The primary sulphur deficiency symptom is leaf yellowing, starting with the newest leaves.

Special considerations:

Nitrogen Fertilization and Protein Content

High protein Red Spring Wheat can be grown in all areas of Manitoba if sufficient nitrogen is available to the plant from the soil or from nitrogen applied as fertilizer. As the nitrogen supply is increased from low to high, an increase in yield results first, followed by an increase in both yield and protein content. Check grain protein content to determine if wheat was adequately fertilized. If protein content is less than 13.2 to 13.5%, insufficient nitrogen was applied to the crop.

Protein content of wheat can be manipulated through additions of N during the growing season. Consider additional N applications in the following situations: 1) a large expected protein premium or 2) if growing conditions suggest higher yield potential than the original target. N taken up by the plant after the boot stage contributes primarily to increased protein. These applications may be made through topdressing of solid or liquid N forms. Rainfall is required for movement of N to the root system. Liquid N may cause leaf-burn damage and should be applied with caution.

Weeds

Wheat is a competitive crop that can choke out certain weeds, depending on the relative time of emergence and the weed density.

Weeds can reduce both yield and quality of the crop. Weed seeds that cannot be cleaned out of wheat and therefore are considered foreign matter causing downgrading are cow cockle, ragweed, tartary buckwheat, vetch, wild oats, corn, peas, volunteer buckwheat and lentils.

Insects

Wireworms, grasshoppers, cutworms, armyworms, aphids, wheat stem sawfly, hessian fly, wheat midge and the wheat stem maggot can damage spring wheat. A dual-purpose seed treatment that includes an insecticide should be used if wireworms are expected to be a problem.

Diseases

Diseases of economic importance to wheat include loose smut or bunt, ergot, leaf and stem rust, fusarium head blight, tan spot, septoria leaf blotch and glume blotch. Where possible, choose varieties of wheat with resistance to diseases common in your area. The severity of tan spot and septoria leaf blotch can be minimized by avoiding planting wheat on wheat stubble.

Harvesting

Swathing

Wheat can be swathed when the kernels have 35 per cent moisture or less without loss of yield, bushel weight or quality. Kernels with 35 per cent moisture are firm and cannot be crushed with thumb and forefinger.

Combining

Wheat kernels with a moisture content of 14 per cent can be safely combined without the need for drying. Kernels with a moisture content of 20 per cent can be combined and dried without loss of quality.

Moisture

Wheat is dry and safe for one year's storage at 14.5 per cent.

Storage

Moulds and mites tend to be inactive when storage moisture is below 13 per cent. If storage temperatures are below 8° C, 3° C and -8° C, insects, moulds and mites, respectively, are inactive.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

WINTER WHEAT

Field Selection

Winter wheat **must** be sown into standing stubble to ensure successful overwintering of the crop. Avoid conflict with the harvest of spring-sown crops by growing an early-maturing spring crop in the field in which you intend to sow winter wheat. Canola stubble is preferred but barley and oat stubble are also suitable. On cereal stubble, avoid the green bridge that can lead to wheat streak mosaic infection. Plant 1-2 weeks after the maturity or destruction of the previous crop. Do not sow winter wheat after spring crops that have poor snow trapping ability, such as field beans, lentils, potatoes and field peas. Avoid seeding into wheat stubble. Straw and chaff from the spring crop must be uniformly spread to facilitate zero-till seeding.

Seeding

Treatments

To prevent seed and seedling rots/blight and common bunt, seed should be treated with a fungicide.

Dates

September 1 to 15 in northern areas. September 1 to 21 in southern areas. Successful overwintering of seedlings requires that the crop be given adequate time in the fall to develop healthy crowns and at least two to three leaves. Temperature and time have a greater influence on winter wheat establishment than soil moisture. Therefore, seed on the optimum date regardless of soil moisture conditions.

Rates

1.5 to 2.5 bu/acre to achieve a target plant population of 20-30 plants/ft^2 See page 7 for calculating optimum seeding rates using plant populations.

Grain yield in winter wheat is determined by the number of heads the crop produces. Row spacing should allow effective trash clearance by zero-till seeding equipment.

Depth

3/4 to 1 inch.

The minimum soil moisture required for germination is quite low and increasing seeding depth to reach moisture may result only in delayed emergence and reduced winter survival. Seed at the prescribed depth regardless of soil moisture.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): 80-120 lb/acre N. These rates are required to maximize the yield potential of winter wheat while maintaining grain protein content. Broadcast ammonium nitrate (34-0-0) in the spring as soon as field conditions allow machinery to travel. Delayed applications result in reduced yield. Broadcasting nitrogen fertilizers such as urea (46-0-0) or urea-ammonium nitrate solution may result in reduced yield due to losses of N through volatilization, especially under warm, dry conditions.

Urea ammonium nitrate (UAN) solutions perform best in a surface or dribble band application. Treating urea with an urease inhibitor will delay volatilization losses for up to 14 days.

Phosphorus (P_2O_5): 30-40 lb/acre. Place all phosphorous in the seed row. Inadequate phosphorus levels can hamper seedling growth and reduce winter survival potential.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 15-30 lb/acre.

Sulphur (S): Low sulphur levels can occur in any Manitoba soils. When required, apply 15 lb/acre of sulphate sulphur.

Special Considerations

Field operations that break down stubble, such as fall banding of fertilizer, reduce the snow trapping potential of a field and increase the risk of winter damage. Placing more than 30 lb/acre of N fertilizer in the seed row may hamper seedling development, which also increases the risk of winter damage.

Weeds

Since fall tillage is not an option, fields infested with perennial grass weeds, such as quackgrass, should be avoided or treated prior to planting. Control of winter annual weeds, such as stinkweed, shepherd's purse, flixweed and narrow-leaved hawk's beard, is particularly important in winter wheat. Best control of winter annual weeds with herbicides is achieved in the fall after the weeds have germinated and right before freeze-up. They may also be treated the following spring, but must be sprayed before the weeds bolt, which occurs in late April or early May.

Winter wheat is a competitive crop that can choke out many weeds, particularly summer annual weeds which emerge in the spring.

Insects

Aphids, wheat curl mite (which spreads wheat streak mosaic virus), wheat stem sawfly, wheat stem maggot and Hessian fly can damage winter wheat. Currently registered winter wheat varieties have low levels of resistance to insect pests.

Diseases

Diseases of economic importance to winter wheat include leaf spots caused by Septoria species, tan spot, powdery mildew, stem and leaf rust, take-all, snow mould, barley yellow dwarf virus, fusarium head blight and wheat streak mosaic virus. Currently registered winter wheat varieties have low levels of resistance to plant disease. Therefore, crop rotation and the use of fungicides are important management considerations.

To reduce the incidence of many diseases, avoid planting winter wheat on wheat stubble. Rust, however, is carried in by wind and its arrival differs from year to year. Grain yield is most affected when rust arrives soon after heading, but losses are small if infection occurs after grain filling has started. Wheat streak-mosaic virus is transferred to winter wheat by a mite. Since the mite lives only on green vegetation, avoid planting winter wheat next to spring wheat fields that have not fully matured.

Harvesting

Winter wheat has little or no seed dormancy, and care must be taken to prevent sprouting once it reaches maturity. Straight combining can reduce the risk of grain sprouting.

Swathing

Wheat can be swathed when the kernels have 35 per cent moisture or less without loss of yield, bushel weight or quality. Kernels with 35 per cent moisture are firm and cannot be crushed with thumb and forefinger.

Combining

Wheat kernels with a moisture content of 14 per cent can be safely combined without the need for drying. Kernels with a moisture content of 20 per cent can be combined and dried without loss of quality.

Moisture

Wheat is dry and safe for one year storage at 14.5 per cent.

Storage

Moulds and mites tend to be inactive when storage moisture is below 13 per cent. If storage temperatures are below 8° C, insects are inactive, and below 3° C moulds become inactive.

For more detailed information on winter wheat, see the *Winter Wheat Production Manual*, at the local Manitoba Agriculture and Food office.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

CANOLA

Field Selection

Canola/rapeseed is a cool-season crop and therefore yields highest when grown in areas where extreme heat and moisture limitations are not usual. Growing crops that are susceptible to sclerotinia too frequently in the rotation can increase the risk of stem rot.

Seeding

Variety Selection

Choose varieties carefully to match the conditions in your area and on your field. Varietal characteristics that are the most important to consider are: blackleg resistance, lodging, crop maturity, tolerance to herbicides and yield. Yield should be considered last since blackleg resistance and lodging tolerance can have the greatest impact on yield. In recent years herbicide tolerant varieties have become available. With an increasing number of varieties with unique characteristics, selection has become more difficult and important to maximize returns.

Treatments

Canola seed is usually treated with both a fungicide and insecticide. The fungicide minimizes seedling losses to damping off, root rot and seed-borne blackleg. The insecticide seed coating is for very early flea beetle control. When flea beetles are expected to be a serious problem, an additional granular insecticide should be blended with the seed to extend the duration of flea beetle control to 3-4 weeks after emergence.

Dates

Argentine canola: May 5 to May 31.
Polish canola: May 5 to June 15.

Rates

Argentine canola: 5-7 lb/acre
Polish canola: 4-6 lb/acre

Plant stands of 7-11 plants/ft^2 or 70-110 plants/m^2 are ideal. Seeding rates on the high end of the recommended range should be used when seeding is late, soil is prone to crusting or there is heavy weed pressure. When emergence problems occur, thin plant stands usually provide a better crop than would a re-seeded crop. See page 7 for calculating optimum seeding rates using plant populations.

Depth

0.5 to 1.5 inches. Seed should be placed only deep enough to reach moisture. If soil is dry down to two-inch depth, seed shallow and wait for rain.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested. Canola is sensitive to high rates of seed-placed fertilizer. Refer to tables 3 and 4 for maximum safe rates of seed-placed N and P. All potassium and sulphur should be applied away from the seed. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-70 lb/acre N following grass and grass-legume breaking and 70-90 lb/acre N following stubble. High-yielding canola requires high nitrogen fertility. However, excessive nitrogen in the soil has been linked to green seed problems. The primary nitrogen deficiency symptoms are yellowing, starting with the older leaves, and thin, spindly stems.

Phosphate (P_2O_5): Apply phosphate rates at 30-40 lb/acre as a sideband or 20 lb/acre with the seed. The primary phosphate deficiency symptom is poor root development and reduced branching with thin, spindly branches.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre. Deficiency symptoms are stunted growth with smaller leaves and thinner stems. Eventually, the edges of lower leaves turn brown and drop off.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields. Canola requires about twice as much sulphur as do cereal crops. A minor sulphur deficiency may not be detected visually but results in significant yield reductions. Major sulphur deficiency symptoms are most visible on the newest leaves and start with yellowing. Leaves showing more severe deficiencies may be cup-shaped, with purple colouration on the edges of leaves. Application of nitrogen alone to a sulphur deficient soil may actually depress yields. Application of fertilizer in a N:S ratio of 8:1 to 5:1 will usually supply adequate sulphur.

Elemental sulphur must be applied one year before the canola crop to allow time for conversion to sulphate.

Weeds

After canola forms a canopy, it is very competitive and chokes out many weeds. Depending on the relative time of emergence and weed density, herbicides may not be necessary, which improves net returns.

Weed seeds that are difficult to remove or cannot be cleaned out of canola and cause downgrading are wild mustard, oriental mustard, brown mustard, ball mustard, cow cockle and cleavers. If canola is going into a field known to be very weedy, consider growing canola varieties that are tolerant to non-selective herbicides.

Insects

Grasshoppers, cutworms, bertha armyworm, flea beetles, diamond back moths, lygus bugs, and root maggots can damage canola.

Diseases

Canola is highly susceptible to sclerotinia, and therefore crop rotations that include field beans, field peas, mustard, sunflowers and other sclerotinia-susceptible crops increase the risk of infection on the canola crop. In canola, several fungicide

treatments are available for control of sclerotinia.

Other major diseases that affect canola are blackleg and alternaria black spot. Varieties resistant to blackleg are available and should be grown in all parts of Manitoba to minimize the impact of this disease.

Harvesting

Swathing

Canola can be swathed when 30-35 per cent of the seeds on the main stem have begun to change from green to brown (equals 30-35 per cent seed moisture). Swathing at this stage minimizes the amount of green seed in the harvested crop. Swathing earlier increases the risk of high green seed content. Once the crop is in the swath, damage from frosts is reduced or avoided. Swathing tall varieties can be difficult, but raising the cutting height reduces the amount of plant material going through the swather.

Desiccation

Canola typically is not desiccated, since the pods shatter easily after desiccation. Desiccation accelerates plant drydown, not plant maturity.

Combining

Canola is considered ready to combine when moisture reaches 10 per cent or less and minimal green seed can be found. Pickup speed should match ground speed to minimize shattering losses. Cylinder speed should be about 500-900 rpm. If the cylinder speed is too fast, seeds will crack. Wind speed should be kept low in order to minimize seed losses with the chaff.

Straw

Canola straw breaks down quite readily. In order to minimize seeding problems in the spring, the straw and chaff should be spread behind the combine rather than placed in a row.

Moisture

Canola is marketed at 10 per cent moisture. For long-term storage, canola should be at 8-9 per cent moisture and below 20° C.

Storage

Once in storage, canola should be cooled since the seed continues a high respiration rate for up to six weeks. This respiration rate creates moist areas (sweating) in the bin that become hot spots. Once binned, canola should be monitored carefully for heating problems.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

FLAX/SOLIN

Although flax and solin seed have different uses and oil profiles, they are grown using the same production practices.

Field Selection

Flax grows well on most prairie soils, except on poorly drained soils and sandy soils because of poor water retention. Medium to heavy-textured soils are preferable. These soils may crust in spring, which can inhibit flax emergence. Avoid fields that had canola or mustard in the previous year, since their crop residues can have a toxic effect on flax.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	**5**
flucarbazone (Everest)	**2**
imazethapyr (Pursuit, Odyssey)	**2**
metsulfuron methyl (Ally)	**2**

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Treatments

Flax is frequently affected by seedling blight. Solin varieties, which have a yellow seed coat, are more susceptible to seedling blight than varieties with a brown seed coat. Fungicide seed treatments reduce the frequency of seedling blight.

Dates

May 10 to May 31. Consult the current *Seed Manitoba* to choose the best-performing varieties under late-seeded conditions. Early-sown flax generally results in the highest yields, highest oil content and best straw quality.

Rates

27-40 lb/acre to achieve a plant stand of 37-56 plants/ft^2. Typical emergence for flax is 50-60 per cent. Seeding rates on the high end of the recommended seeding range should be used for ground prone to crusting, when seeding late or under heavy weed pressure. See page 7 for calculating optimum seeding rates using plant population.

Depth

1 to 1.5 inches. Seed should be placed only deep enough to reach moisture. If cultivation is required before seeding, the seed bed may benefit from packing before or after seeding.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested.

Flax is easily injured by seed placed fertilizer. All fertilizer should be applied away from the seed.

If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply no N following fallow or legume breaking, 0-40 lb/acre N following grass and grass-legume breaking and 40-60 lb/acre N following stubble. The primary nitrogen deficiency symptoms are stunting with small leaves that are yellowing, starting with the older leaves.

Phosphate (P_2O_5) : Apply phosphate at 30-40 lb/acre in a sideband or placed below the seed. The primary phosphate deficiency symptom is a darker leaf colour than normal, along with stunting, smaller leaves and thinner stem.

Potassium (K_2O) : On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre. Deficiency symptoms are stunted growth and leaf tip browning on the lower leaves.

Sulphur (S): Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields. Apply sulphate sulphur at 15 lb/acre when required. The primary sulphur deficiency symptom is leaf yellowing, starting with the newest leaves.

Special considerations

Chlorosis can occur on flax when soil moisture is high, particularly on calcareous (high lime) soils. This symptom may be caused by herbicide injury, soil compaction or *deficiencies in zinc*. The flax variety AC Emerson has shown the greatest tolerance to chlorosis conditions.

Weeds

Weeds can reduce yield and reduce the quality of flax. Weed control in flax is particularly important because flax is a relatively non-competitive crop.

Weed seeds that are difficult to remove or cannot be cleaned out of flax and therefore are considered foreign material and cause downgrading are volunteer mustard, volunteer canola, wild oats and smartweed.

Insects

Grasshoppers, cutworms, army cutworm, bertha armyworm, beet webworms, aphids, aster leafhoppers and wireworms can damage flax.

Diseases

Seedling blight is the most common disease problem in flax and can be managed with the use of seed treatments. Fusarium wilt is also common and can be managed through the use of resistant varieties. Other diseases that also may affect flax and occasionally are economically important are pasmo, and stem break and browning.

Harvesting

Swathing

Flax can be swathed when 75 per cent of the bolls are brown. Swathing is preferred to straight combining when the crop is not uniform in maturity, or if weeds are present. Once in a swath the seed is less susceptible to frost damage.

Desiccation

Flax can be desiccated to hasten dry-down after the crop has reached physiological maturity (75 per cent of bolls are brown). Stem dry-down in particular can be hastened to reduce the interval before harvest.

Timing

Immature seeds will turn black as a result of an early frost. However, desiccation or swathing prematurely will reduce yield.

Combining

Flax seed with a moisture content of 10 per cent can be safely combined without the need for drying. The combine must be adjusted correctly to minimize seed coat damage to flax. Solin is particularly prone to seed damage. If seed is very dry and the cylinder speed is too high, significant seed damage can occur.

Straw

Flax straw can cause problems in seeding subsequent crops if it is chopped and spread, since the straw decomposes very slowly. The straw can be baled and sold to several industries that process the straw. To be sold, straw must be free of weeds and garbage. As a last resort, the straw can be burned.

Moisture

Flax is safe for storage at 10 per cent moisture or less.

Storage

Once put into storage, flax should be cooled, since the seed continues a high respiration rate for up to six weeks. This respiration rate creates moist areas in the bin that become hot spots.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

SUNFLOWERS

Field Selection

Sunflowers grow best on loam, silty loam and silty clay loam soils with good drainage. Sunflowers have a low tolerance of saline conditions, and therefore soils with moderate to high levels of salinity should be avoided. Sunflowers are sensitive to herbicide residues, such as clopyralid (Lontrel, Curtail) and imazethapyr (Pursuit, Odyssey).

Seeding

Treatments

Seeds can be treated with a fungicide to control downy mildew, but there are no registered treatments for seedling blight.

Dates

Sunflower seeding should usually begin sometimes after May 1 and ideally be finished by June 1. Seedlings are relatively frost-tolerant up to the four-leaf stage. Confection varieties are longer maturing than oilseed types. If seeding is delayed into the first week in June, switching to oilseed types is recommended as well as choosing earlier maturing varieties.

Rates

Seeding rate for sunflowers depends on the row spacing and sunflower type. Oil-type sunflower populations range from 16,000-20,000 plants/acre or 0.6 plants/ft^2, but confection-type sunflowers should not exceed 18,000 plants/acre or 0.4 plants/ft^2 to ensure large seed size. Seeding rates for both oil and confection-type sunflowers should be adjusted when germination is low and for the number of weed control harrowing operations expected. See page 7 for calculating optimum seeding rates using plant population.

Solid Seeding

Recommended row spacing for solid seeding is 10 to 12 inches for both confection and oil type sunflowers. Plant populations should remain the same as stated above regardless of row spacing. The sunflower plant will compensate for difference in plant population through changes in seed and head size. These changes are more noticeable in confection and caution should be taken when calculating the seeding rates. See page 7 for calculating optimum seeding rates using plant populations.

Depth

Sunflowers need to be placed in moisture but not deeper than three inches. The idea seeding depth is 1.5-2 inches deep. Planting equipment should firm the soil over the seed row to maintain a moist seedbed.

Fertilizer

General

Sunflowers take up and remove modest levels of nutrients compared to barley or canola. For specific recommendations on fertilizer rates, have your soil tested. Phosphate and potassium should be side-banded to the sunflower row, along with some or all nitrogen. Nitrogen is often banded between the rows after planting. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-55 lb/acre N following grass and grass-legume breaking and 55-90 lb/acre N following stubble. The primary nitrogen deficiency symptoms are reduced growth (plant height) and general chlorosis, with the lower leaves showing a greater degree of chlorosis than the upper leaves.

Table 10. Seed density of sunflowers as a function of row spacing.

	Row spacing – inches				
	16	18	22	30	36
Plants/acre	Average seed spacing within row – inches				
16,000	23	20	16	12	10
18,000	20	17	14	10	9
20,000	18	16	13	9	8

Sunflower seed is sold in different sizes and seeding rate must be adjusted accordingly. The following table defines the seed sizes and the associated seed weight.

Table 11. Sunflower seed size and associated seed weight.

Oil-type sunflowers		Confection-type sunflowers	
Seed Size	**Seeds/lb**	**Seed Size**	**Seeds/lb**
No. 2	5,000-6,000	Medium	4,000-5,000
No. 3	6,000-7,000	Large	3,000-4,000
No. 4	7,000-9,000	Extra Large	2,000-3,000

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre. The primary phosphate deficiency symptom is reduced growth and dark-grey necrosis of the lower leaves of the plant.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 15-30 lb/acre potash in a sideband or 30-60 lb/acre broadcast. The primary potassium-deficiency symptom is yellowing, with large necrotic patches on the oldest leaves.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields. The primary sulphur deficiency symptom is a general chlorosis of the plant, with the youngest leaves showing a greater degree of yellowing than the older leaves.

Special considerations:

Sunflowers have deep tap roots that can obtain water and nutrients 5-6 feet deep in the soil. These reserves of water and nutrients are unavailable to most other annual crops, making sunflower a good rotational crop.

Sunflowers are very susceptible to seed-placed fertilizer injury. To avoid seedling injury from fertilizer, best results are obtained by placing starter fertilizer in a band two inches below and beside the seed.

Weeds

In sunflowers, weeds can be controlled by using pre-emergent herbicides, harrowing before crop emergence, inter-row cultivation when the crop is in the 4-6 leaf stage and post-emergent herbicides. Weeds should be removed within the first four weeks of crop growth to minimize yield losses. Weeds such as Canada thistle and perennial sow thistle cannot be controlled in sunflowers, and must be controlled before growing this crop.

Insects

Cutworms, sunflower beetle, sunflower weevil, banded sunflower moth and the sunflower midge can damage sunflowers.

Diseases

Sclerotinia is the most common disease in sunflowers. Sclerotinia can infect different parts of the plant, causing basal stem rot, head rot and mid-stem infections. Downy mildew can be controlled with seed treatments. Hybrids differ in their susceptibility to rust, verticillium wilt and downy mildew. Consult *Seed Manitoba* for information on current hybrids.

Pollination

Sunflower yields benefit from honeybee pollination. Sunflowers produce a large supply of nectar for honeybees, and therefore colonies located near the field will actively forage and pollinate the crop.

Harvesting

Timing

Sunflowers are usually the last crop to be harvested in fall, since fall frosts help in drying down the crop. The period between maturity and harvest should be kept as short as possible to minimize losses from bird damage and head-rot diseases.

Desiccation

Chemical desiccation is used to hasten dry-down of the sunflower heads. Desiccation is most effective before a killing frost in enhancing head dry-down but should not be applied before the back of the sunflower head turns yellow and the bracts are brown and dry. At this stage the plant is said to be physiologically mature and seed moisture will be 20 to 50 per cent. Refer to the current *Guide to Crop Protection* for details on desiccation.

Combining

Sunflowers can be safely combined when the seed moisture reaches about 20 per cent. Sunflowers can easily shatter if heads are very dry, and therefore combine speed must be slowed accordingly. Cylinder speeds range from 300-500 rpm, with concave settings quite open (one inch in front and 3/4 inch in rear) to minimize seed breakage and dehulling. Using the slowest cylinder speeds with the largest openings will result in the least seed damage.

Harvesting Attachments

Combines that are suitable for harvesting small grain will be adequate to harvest sunflowers. A proper header attachment is necessary to reduce shattering losses and harvest efficiently.

There are two types of attachments:

1. The pan header, which is mounted on traditional straight cut header and is suitable for both row crop and solid seeding.
2. The all crop header, which is only suitable for row crop planting.

Storage

Sunflower seed is safe to store at moisture content of 9.5 per cent or less. At 10 to 12 per cent moisture content seed can be stored in bins with aeration. Any moisture content over 12 per cent will require drying. Oil-type sunflowers can be dried with temperatures of 71 – 104°C (160 - 220°F) but confection types may scorch or wrinkle with these temperatures. Sunflower seed should be cooled before storage, since even sunflowers at 8.5 per cent moisture can spoil if stored when warm.

PULSE CROPS

Inoculation of Pulse Crops

(Field Peas, Lentils, Fababeans, and Soybeans)

Pulse crops are legumes belonging to the same plant family as alfalfa and sweet clover. They have the capacity to capture atmospheric nitrogen and transform it into usable plant nitrogen in the form of amino acids and proteins. This process is called "nitrogen fixation."

Nitrogen (N) fixation takes place in nodules attached to the roots of legumes. Nodules are large bundles of cells that form when *Rhizobium* bacteria invade the root hairs, shortly after germination. Rapid cell multiplication takes place to form the gall-like structures.

To ensure rapid development and optimum N-fixing activity, sufficient numbers of bacterial (rhizobial) cells must be close to the seed. Often, soils do not contain rhizobia of the right types, or in sufficient numbers for the pulse crop being grown. Therefore, rhizobia must be added to the seed, or to the soil before seeding. This is called inoculation.

Inoculation Methods

Two methods of inoculating pulse crops are recommended:

1. Peat-based powder inoculum is applied to the seed as a wet slurry. The seed should be treated as close to seeding as possible, and preferably include a "sticker" to improve the inoculum sticking to the seed coat. Self-sticking liquid inoculants are now available for many crops.

2.Granular peat or clay-based inoculum is added to the seed row at the time of seeding.

These methods ensure that each seed is in contact with inoculant (rhizobia cells).

Specific Inoculant

Specific inoculants for all pulse crops are available commercially.

It is essential that *the inoculant specific to the crop being sown* be applied. Check the inoculant package to ensure that it is specific to the crop you are producing.

Expiry Date

Packages should have an expiry date stamped on them, so a check can be made to ensure that the inoculant is fresh. If it is purchased well before seeding, store in a cool, dark place (UV light rapidly kills the rhizobia). Apply inoculant to the seed immediately before seeding, and protect all treated seed from sunlight. Do not use old (last year's) inoculant.

Field beans are the least infected by rhizobia. Some plants are very well nodulated, while others carry few if any nodules in spite of adequate inoculation. Yields of field beans have responded more to N fertilizations than to inoculation.

Check for nodulation and nodule activity. It is a good idea to check nodulation three to four weeks following emergence. Carefully dig up plants, preserving the finer roots, and look for nodules. Most nodules will be congregated around the main (tap) root. At this stage, they will be small but active. Nodules that are fixing nitrogen will be pink inside, and slicing the nodule with a knife or thumbnail will reveal this colour. The absence of the pink colour indicates an inactive nodule.

FABABEANS

Field Selection

Fababeans are well adapted to clay or clay loam soils with good moisture, provided surface drainage is effective. Fababeans are very sensitive to certain herbicide residues.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	5
clopyralid (Lontrel, Curtail)	4
ethametsulfuron (Muster)	2
ethalfluralin (Edge)	3
flucarbazone (Everest)	2
metsulfuron methyl (Ally)	2
sulfosulfuron (Sundance)	2

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Treatments

There are no registered seed treatments for use on fababean seed.

Dates

Fababeans should be seeded early in the growing season. A long growing season is required to optimize yield. Depending on variety, days to maturity range from 94 to 102. Yield will usually be reduced if fababeans are seeded after the third week in May.

Rates

Seed at 150-180 lb/acre to achieve a plant population of 4-5 plants/ft^2. Seeding rate will vary with seed size and germination. See page 7 for calculating optimum seeding rates using plant populations. Seed costs are a significant expenditure when considering this crop.

Depth

1.5 to 3 inches. Seed should be sown to moisture. Increase seeding depth with droughty soils. Seeding at a uniform depth should result in uniform emergence and maturity. Emergence is slow due to large seed size and deep seeding.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested. To maximize the nitrogen fixation ability of fababeans, seed should be inoculated. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Nitrogen is not recommended. Inoculate at seeding with appropriate rhizobia.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre as a sideband or 20 lb/acre with the seed.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields.

Weeds

Fababeans do not compete well with weeds during the establishment period. Broadleaf herbicide options are limited; therefore, sowing into a relatively clean field is important.

Insects

Aphids and lygus bugs can damage fababeans. Lygus bugs can cause hull perforations in fababeans, and 1% is the upper limit of perforated damage acceptable for fababeans to be graded No. 1 Canada by the Canadian Grain Commission.

Diseases

Ascochyta blight causes bean discolouration and shrinking. Look for tan leaf spots, reddish-brown stem spots and sunken tan to black spots on pods. Use disease-free seed. Botrytis is characterized by reddish-brown spots on leaves, stems and pods that range from small dots to large lesions. Sclerotinia is much less damaging, compared with canola or sunflower crops. Use a one-in-four-year crop rotation between susceptible crops.

Harvesting

Swathing

Swathing is recommended, as fababeans require a 2-3 week dry-down period once swathed. Fababeans should be swathed at 35-45 per cent seed moisture content, which occurs when lower leaves drop and lower pods turn dark, or in the first week of September, whichever comes first. The lower dark pods make up 10-15 per cent of the pods on the plant. Fababeans should be harvested at 18-20 per cent seed moisture. Crops cut 7-10 days before the first fall frost will likely have no seed damage.

Combining

Use slow cylinder speed (300 rpm) with a wide concave clearance, and lots of air. Operate combine unloading auger at low rpm speeds.

Storage

Fababeans can safely be stored at 16 per cent seed moisture content. When combined tough (greater than 16 per cent moisture), fababeans should be aerated to 16 per cent seed moisture content. Do not exceed 32° C drying temperatures.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

FIELD BEAN

Field Selection

Field beans grow well on a variety of well-drained soil types, and are more limited by length of growing season and flooding than any other factors. Beans can be grown on fields with rocks, but the field must be rolled before bean emergence. Field beans are sensitive to a number of herbicide residues.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	**5**
clopyralid (Lontrel, Curtail)	**4**
metsulfuron methyl (Ally)	**2**
sulfosulfuron (Sundance)	**2**
trifluralin (Treflan, Rival)	**3**

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Field beans have traditionally been grown as a row crop. However, with new upright varieties, field beans can be produced solid-seeded with slight modifications to conventional seeding and harvesting equipment.

Treatments

Field bean plants can be affected by seed and seedling rots/blights and bacterial blight. Seed should be treated with a fungicide seed treatment to prevent root rot and reduce the chance of seed-borne diseases such as anthracnose. Certified bean seed is usually treated with a combination of fungicides.

Dates

Beans are very sensitive to frost; therefore, seed later in the growing season, when the risk of a killing spring frost is over and soil temperature is greater than 10° C. Seeding can start by May 20 in most bean-growing areas of the province. Early-maturing varieties are available for areas with a restricted growing season.

Rates

Seeding rate will vary with seed size, germination, row spacing and bean type. A final plant stand of 70,000 to 100,000 plants/acre is suitable for row crop production. Plant populations for narrower rows (or solid-seeding) can be increased to optimize yield and make crop cutting easier.

Table 12. Bean plants per m of row (39") at various row spacings and plant populations.

Plants /acre	Number of plants/m of row Row Width (inches)			
	6-8"	12-16"	18-24"	30"
100,000	4.5	9.0	13.6	19.4
120,000	5.4	10.8	16.3	23.2
140,000	6.3	12.6	19.0	27.1
160,000	7.2	14.4	21.7	31.0

The following indicates plant populations by row width for navy beans:

6"	150,000 plants/acre or 3.4 plants/ft^2
12"	135,000 plants/acre or 3.0 plants/ft^2
22"	120,000 plants/acre or 2.7 plants/ft^2
30"	100,000 plants/acre or 2.3 plants/ft^2

See page 7 for for calculating optimum seeding rate based on seed size and germination.

Depth

1 to 2.5 inches. Seed should be sown to moisture. On soils with a low water-holding capacity, increase seeding depth to a maximum of 2.5 inches. Seeding at a uniform depth should result in uniform emergence and maturity.

Special considerations:

Field beans are easily cracked by handling and seeding equipment. Very dry seed will crack easily and the seed will not grow. Using conventional (solid) air seeding equipment increases the chance of seed cracking.

Solid-seeded beans can be rolled before emergence to provide a smooth, stone-free surface to improve harvest conditions.

Fertilizer

General

For specific recommendations, have your soil tested. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Field beans are rather inefficient at fixing N and obtain less than half of their requirements through fixation. Recent field studies indicate that treatment with *Rhizobium* inoculant is ineffective on current bean cultivars grown in Manitoba but great yield response occurs with nitrogen fertilizer. Growers should consider application of 40-60 lb N/ac where typically yield is less than 1500 lb/ac and 60-90 lb N/ac where yields regularly exceed 1500 lb/ac. In shorter season growing areas there is more potential to increase yield at reduced risk by fertilizing with nitrogen than by seeding later maturing cultivars. In certain situations high N rates may cause an increase in foliage growth and disease severity (particularly white mould), delay maturity and reduce the effectiveness of native rhizobium. These problems have not been observed in recent years. Fall soil sampling is essential so that residual nitrate levels are accounted for when fertilizing succeeding crops.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre as a sideband or 20 lb/acre with the seed. This seed placed rate is for narrow-row (solid-seeded) seeded beans, where the seed-bed utilization is high. Applying these rates in wide-row seeded beans may cause stand reduction.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields.

Zinc: Beans may respond to zinc application if soil is very low in available zinc. This is most commonly associated with high pH or eroded soils.

Weeds

Grassy weeds can be controlled through the use of crop rotation and herbicide application. Herbicides for the control of certain broadleaf weeds (Canada thistle, perennial sow thistle and dandelion) either are not available or provide less than acceptable control.

Beans must be sown into fields free of difficult-to-control perennial weeds. Consider applying preharvest herbicides the year before growing beans. The use of inter-row cultivation and band spraying of herbicides can reduce weed control costs. Beans seeded in narrow rows will compete better with weeds; however, they do not allow for inter-row cultivation. Beans sown on 22-inch spacing or greater, and not cultivated, will be very uncompetitive with weeds.

Insects

Grasshoppers, lygus bugs and leafhoppers can damage field beans. Cutworms, seedcorn maggots, and wireworms can be early season pests of beans.

Diseases

The four major diseases affecting field beans are white mould (sclerotinia), rust, bacterial blight and anthracnose.

White mould is most serious during wet growing conditions. The fungus causes a white-coloured, soft, watery rot to occur. The disease can be managed by applying a registered fungicide, just as the crop starts to flower. Fungicides will protect the blossoms, ultimately protecting the yield potential of the plant. Excellent coverage of the blossoms is critical for controlling the disease. Consult the *Guide to Crop Protection* for specific information on fungicides. For the management of white mould, field beans and other susceptible crops (including sunflower, canola, potato, and peas), should be grown on the same field only once in four years. Draining fields to allow for the removal of water from low areas will reduce soil moisture and reduce the risk of the disease.

Rust is a defoliating fungal disease that is an occasional problem later in the season. Pinto beans are more susceptible. Early symptoms of the disease are red spots on the leaves, defined by a yellow halo. Over time, the spots turn black. Rust is most severe on late-planted and heavily fertilized beans. There are no registered fungicides for rust.

Bacterial blight can be caused by any of four different bacterial organisms. Blights are seed-borne and spread within the crop by rain splash. Blights cause leaf lesions and defoliation and lesions on pods. Lesions are large and irregularly shaped, and surrounded by a distinct yellow zone. Infected pods develop greasy-appearing spots surrounded by red margins. Infected seed will be stained and contribute to pick (quality gradeout due to visual discoloration).

Anthracnose is a fungal disease with several different races (strains) that can reduce bean yield and seed quality. anthracnose is primarily seed-borne but can survive on infected bean residue. Early symptoms are small red brick coloured lesions on the lower leaf surface with later lesions progressing to the upper leaf surface to stems and pods and potentially to the seed. Anthacnose is managed through use of resistant varieties (limited), seed treatment that specifically targets anthracnose, e.g. DCT, use of certified seed and proper crop rotation.

Harvesting

Desiccation

Desiccation is useful when the crop is not uniform or weeds are prevalent. Consult the *Guide to Crop Protection* for specific use of desiccants or harvest-management products.

Undercutting/windrowing (row-cropped)

Cutting can start when the bean seed

is at 20 per cent moisture. At that time, most of the leaves have dropped. Avoid cutting during excessively hot and dry periods of the day to avoid shattering losses.
Windrowing is essential for producing a large enough swath to efficiently combine. Windrowing should also be done during cooler, damper times of the day to reduce shattering losses.

Swathing (solid-seeded)

If field beans are swathed, a pickup reel will help in moving the plant material off the cutter bar and onto the canvas. Swaths are very prone to blowing so, when possible, beans should be combined immediately after swathing. Lifter guards on the swather will allow for cutting close to the soil surface.

Direct Harvesting (solid-seeded)

An all-crop header, flex header, floating cutter bar or a straight combine attachment can be used to cut and thresh beans. Combining at an angle to the direction of the row will often result in less combining loss and less wear on your knifes. Direct harvesting will be effective only for varieties that stand up at harvest and carry pods greater than 1.5 inches from the ground.

Combining

Treat beans with care. Low cylinder speed (150-300 rpm), a seed moisture of 18 per cent and a wide concave should reduce seed splitting and seed-coat cracking. Cylinder speed may need to be increased to thresh all the seed out of the pod. Although conventional rasp-bar cylinder and rotary combines can be used, a spike-tooth cylinder or rotary combine will handle the beans more gently and maintain quality. Combine rows and swaths to keep the combine as full as possible to reduce cracking.

Storage and Handling

Beans can safely be stored at 16 per cent seed moisture content. When combined tough, beans should be aerated to 16 per cent. Beans should be moved with a belt conveyor to avoid seed-coat injury or seed cracking. Belt conveyors will fit under most hopper bottom bins. When beans are stored on concrete, they can be picked up with a front-end loader.

Grade

Split seeds, cracked seed coats and damaged beans (including frosted, discoloured, earth-tagged seeds and stones) are all downgrading factors. All classes of beans can tolerate no more than 0.05 per cent ergot or sclerotinia. Downgraded beans do not have alternative markets for feed.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

FIELD PEAS

Field Selection

Peas grow well on most well-drained soil types. Fields containing rocks can be rolled before emergence, up to the 5-6 node stage of the peas. Field peas are sensitive to a number of herbicide residues.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	**5**
clopyralid (Lontrel, Curtail)	**4**
flucarbazone (Everest)	**2**
metsulfuron methyl (Ally)	**2**
sulfosulfuron (Sundance)	**2**

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Treatments

Peas can be affected by seed and seedling rots/blights and should be treated with a fungicide seed treatment. The more blocky and irregular the seed shape, the more potential for seed infection. For registered seed treatments, refer to the current *Guide to Crop Protection*.

Dates

Peas can be seeded early in the growing season. Very early maturing varieties are available for areas with a restricted growing season. These varieties generally mature one week before those rated as medium. Yield will usually be reduced if peas are seeded after the third week in May.

Rates

Seeding rate will vary with seed size and germination. Generally, a final plant stand of 7-8 plants/ft^2 or 70 to 80 plants/m^2 will optimize yield. See page 7 for calculating optimum seeding rates using plant populations. Table 13 shows the seed required (bu/acre) with various seed sizes.

Depth

1 to 2 inches. Seed should be sown to moisture. Seeding depth should be increased with soils with a low water-holding capacity. Seeding at a uniform depth should result in uniform emergence and maturity.

Fertilizer

General

To maximize the nitrogen fixation ability of peas, they should be inoculated. For specific recommendations, have your soil tested. If soil analysis is not available, a general recommendation is as follows:

Table 13. Field pea seeding rates.

	Seed Weight (g/1000 seeds)						
	180	200	220	240	260	280	300
Bushels/Acre	1.6-1.8	1.8-2.0	2.0-2.2	2.1-2.3	2.3-2.5	2.5-2.7	2.7-3.0

Nitrogen (N): Nitrogen is not recommended. Inoculate at seeding with appropriate Rhizobia.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre as a sideband or 20 lb/acre with the seed.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to determine the available sulphur status of fields.

Weeds

Grassy weeds are easily controlled through crop rotation and herbicide application. Herbicides for the control of certain broadleaf weeds (Canada thistle, perennial sow thistle and dandelion) either are not available or provide less than acceptable control. Consider applying preharvest herbicides the year before growing peas to control difficult perennial weeds like thistles and quackgrass. Sowing early, into a clean field, with a target plant population of at least 70 plants/m^2 will make the pea crop more competitive with weeds. Leafed pea varieties are often more competitive than semi-leafless varieties.

Insects

Cutworms, seedcorn maggot, and wireworms can be early season pests of peas. Pea aphids are the most significant insect pest later in the season.

Diseases

Diseases in field pea are seed and seedling rots and blights, mycosphaerella blight and powdery mildew.

Disease-free seed and seed treatment should be used to minimize seed and seedling rots and blights. Crop rotation and use of disease-free seed are critical for mycosphaerella blight control. A fungicide application can reduce the effect of mycosphaerella blight. Powdery mildew can be managed by early seeding, use of resistant varieties and fungicide application.

Harvesting

Desiccation

Desiccation helps to speed dry-down when the crop is not uniform in maturity or weeds are prevalent. Desiccants will not improve crop maturity. Refer to the *Guide to Crop Protection* for more information.

Swathing

If peas are swathed, a pick-up reel will help in moving the plant material off the cutter bar and onto the canvas. Swaths are very prone to blowing. When possible, they should be combined immediately after swathing. Lifter guards on the swather will allow for cutting close to the soil surface.

Direct Harvesting

A Sund, Rake Up pickup or flex header (flexible cutter bar) can be used to direct-harvest peas. Peas should be harvested on the tough side (17-20 per cent seed moisture content) to reduce splitting and seed coat cracking. Cylinder speed of the combine should be set at 300-600

rpm; slow the cylinder down as the seed moisture content drops, set concave at 5/8" front; 3/8" rear - chaffer at 5/8" - lower sieve setting at 3/8" - sieve size 7/16". Use high air flow for good separation. Operate unloading auger slowly to reduce splitting and seed coat cracking.

Straw Management

Pea straw can be well-chopped when harvested during hot and dry conditions. If not well-chopped, pea straw can cause branching when seeding the following crop.

Storage and Handling

Peas can safely be stored at 16 per cent. When combined tough, peas should be aerated to 16 per cent seed moisture content. Peas used for seed or human consumption should be moved with a belt conveyor to avoid seed-coat injury or seed cracking.

Grade

Number 2 Yellow is the minimum grade for processing and many export markets. #1 and #2 Green are required for export markets. Major factors in downgrading peas are pale colour in greens, soil particles, splits, cracked seed coats and shrivelled, immature seed.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

LENTILS

Field Selection

Lentils grow well on most well drained soil types. Yield can be severely reduced on wet, poorly drained soils, as root diseases will increase. Fields can be rolled post-emergence, up to the 4-6 inch height. Lentils are sensitive to herbicide residues.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	**5**
clopyralid (Lontrel, Curtail)	**4**
ethametsulfuron (Muster)	**2**
flucarbazone (Everest)	**2**
imazethapyr (Pursuit, Odyssey)	**2**
metsulfuron methyl (Ally)	**2**
sulfosulfuron (Sundance)	**2**

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Treatments

Lentil seed can be treated with a fungicide treatment for the control of seed-borne ascochyta, and root rots and blights. For recommendations consult the current *Guide to Crop Protection*.

Dates

Lentils can be seeded early in the growing season. Lentils will tolerate several degrees of frost and will regrow if the above-ground portion is damaged. Yield will usually be reduced if lentils are seeded after the third week in May.

Days to maturity by market class

market class	days to maturity
small red cotyledon	91
small yellow cotyledon	91
medium yellow cotyledon	96
large yellow cotyledon	100

Rates

Seeding rate will vary with seed size and germination. Target a plant population of approximately 10-14 plants/ft^2. Small lentil varieties, such as Eston and Dark speckled, should be seeded at a rate of 30-40 lb/acre. Larger-seeded varieties, such as Laird, should be seeded at a rate of 70-80 lb/acre. See page 7 for calculating optimum seeding rates using plant populations.

Depth

1 to 1.5 inches. Seed should be sown to moisture. Seeding depth should be increased in soils with a low water-holding capacity.

Fertilizer

General

For specific recommendations, have your soil tested. To maximize the nitrogen fixation ability, lentils should be inoculated. If soil analysis is not available, general recommendations are as follows:

Nitrogen (N): Nitrogen is not recommended. Treat at seeding with appropriate rhizobial inoculant.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre as a sideband or 20 lb/acre with the seed.

Potassium (K_2O): On sandy-textured or organic soils apply potassium at rates of 30-60 lb/acre.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A

soil test is recommended to determine the available sulphur status of fields.

Weeds

Weed control in lentils is important because lentils are a relatively non-competitive crop. Herbicides for the control of certain broadleaf weeds (Canada thistle, perennial sow thistle and dandelion) either are not available or provide less than acceptable control. Lentils must be sown to fields free of difficult-to-control perennial weeds such as Canada thistle and perennial sow thistle. Consider applying pre-harvest herbicides the year before growing lentils for perennial weed control.

Insects

Cutworms may be a problem in lentils early in the season. Grasshoppers can also be a problem in lentils.

Diseases

Diseases in lentils are ascochyta blight, anthracnose, fusarium root rot, rhizoctonia root rot and sclerotinia. Anthracnose and ascochyta blight can cause severe yield loss in lentils.

Anthracnose can be first noticed as white to gray or cream-coloured spots develop on the leaflets and stem. They usually appear on the base of the stem and move up the plant canopy. Leaf drop occurs as the disease progresses.

Ascochyta blight also starts with light-gray to tan spots occurring on the leaflets, stems and pods, but will have a dark margin around the spot. The centres of the spots turn light-coloured and develop small black spots in them. The crop will look blighted in appearance. Both diseases can be managed by using a foliar fungicide program.

Crop rotation (growing lentils only once in four years), and the use of certified, disease-free seed will help to minimize the disease.

Root rots become evident at any stage from emergence to maturity. Individual plants become stunted, turn yellow, and die. Essentially the root system has been destroyed. Crop rotation may help. However, the wide host range of these diseases makes this a less than effective option.

Harvesting

Desiccation

Desiccation is useful when the crop is not uniform or weeds are prevalent. Consult the *Guide to Crop Protection* for specific directions for use.

Swathing

A pickup reel will help in moving the plant material off the cutter bar onto the canvas. Swaths are very prone to blowing, so whenever possible they should be combined immediately after swathing. Lifter guards on the swather will allow for cutting close to the soil surface.

Combining

Lentils are considered dry at 14 per cent moisture. However, lentils should be harvested at 16-18 per cent to avoid excess splitting or cracking of the seed. Lentils thresh easily and a slow cylinder speed (400 rpm) will reduce cracking. Set the concave wide enough to avoid cracking.

Storage and Handling

Lentils can be safely be stored at 16 per cent. When combined tough, lentils should be aerated to 14-16 per cent seed moisture content.

Grade

The major quality concerns in lentil grading are colour (staining, dirt tag) and damage due to heating and peeled, split or broken seed, as well as foreign material.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

SOYBEANS

Field Selection

Soybeans are adapted to a wide range of soil types in south-central Manitoba. Loamy soils are ideal. While heavy clay soils can lead to planting and emergence problems, once established, soybeans perform reasonably well. Soybean performance can be poor on sandy soils prone to drought stress.

Temperature is a main limiting factor - soybean is a heat-loving crop. Current varieties are rated at 2375 - 2675 corn heat units (Ontario data), limiting suitability mainly to the south-central area of the province.

Seeding

Treatments:

Soybean is susceptible to seed and seedling rots. Use a recommended fungicide seed treatment.

Date:

May 15 to 25, or when the average soil temperature has warmed up to at least 10° C, 18 - 22° C is ideal. Seedlings can tolerate a light spring frost (-2.8° C for a short period), but cannot recover if damaged. Later seeding results in decreased plant height, lower pods and reduced yields.

Rate/Stand Density

The ideal plant density is estimated at 180,000 to 210,000 plants/acre or 4 plants/ft^2 (40 plants/m^2).

Depending on seed size, this stand density will require a seeding rate of 70-120 lb/acre. By branching, soybean can compensate for reduced stands. Experience from Ontario suggests that at a stand of 50 per cent less than optimum, expected yield will be 24

per cent less, and replanting should be considered. See page 7 for calculating optimum seeding rates using plant populations.

Depth

0.75 to 1.5 inches deep. Within this range, seed shallow in loamy or heavy soils, or with early seeding dates; sow slightly deeper in lighter soils to ensure that the seed remains in contact with moist soil. Soybeans are sensitive to deep seeding, which results in poor emergence and increased risk of soil-borne diseases.

Fertilizer

General

Soybeans must be inoculated at sowing, especially with the first crop grown on a field. First-time soybean growers should consider using granular inoculant. Although more expensive, it offers the most reliable nodulation and protection from dry soils, low or high pH and seed treatments.

Delivery of granular inoculants to the seed row may require granular attachments for grain drills or air seeders.

Peat-based and liquid inoculants are also available. After one or two well-nodulated soybean crops, the rhizobia population in a field may be adequate for subsequent crops. Soybean crops grown on poorly-drained soils with high carbonate and salinity levels may be prone to iron chlorosis, which causes yellowing of plants.

Nitrogen (N): Not recommended. If nodulation does not occur and the soybeans are yellowing at early flowering consider a broadcast application of nitrogen. Apply 50 lb/acre N as broadcast ammonium nitrate.

Phosphate (P_2O_5): Phosphorus is recommended at 30 to 40 lb/acre. Apply as a sideband application or as an application one inch directly below the seed. If applied with the seed, the maximum rate recommended is 20 lb/acre. This seed placed rate is for soybeans seeded in narrow rows, where seed bed utilization is high. Applying these rates to soybeans in wide rows may cause stand reductions.

Potassium (K_2O): Sands, sandy loam and organic soils are frequently low in available potassium. On these soils, apply 30 to 60 lb/acre potash. Potassium should be placed away from the seed.

Sulphur (S): Sulphate sulphur at a rate of 20 lb/acre is recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this, a soil test is recommended to determine the available sulphur status of your fields.

Weeds

Soybean seedlings are non-competitive. Weed management is primarily by herbicide. Cultivation is possible if soybeans are grown as a row crop. In this case, herbicides can be applied in a band over the row.

Insects

Insects that feed on the leaves and pods include grasshoppers, the corn earworm and the fall armyworm. Under most conditions, moderate defoliation early in the season has no appreciable effect on soybean yield. Fifty per cent defoliation before flowering results in an average yield loss of only three per cent. As the soybean plant reaches the flowering and pod-filling stage, defoliation is a greater threat to yield and controls may be needed.

Some soil-inhabiting insects may also feed on soybeans. Seed corn maggots feed on the seeds, which may result in seeds not germinating. Less-severely damaged seeds that germinate may produce week seedlings that die. This insect is seldom a problem, except when weather conditions or seed quality delay seedling emergence. Risk can be reduced by applying seed treatments containing insecticides. Wireworms feed on seeds and seedlings, and damage is most likely in low-lying and poorly drained portions of the field. White grubs are root feeders, and damage symptoms may vary from dead to stunted, yellow plants.

Diseases

Root rot may occur under moist soil conditions. Use treated seed and/or resistant varieties to minimize risk. Soybean is susceptible to sclerotinia (white mould), so avoid other sclerotinia-susceptible crops in rotations, and ensure that rotation is of adequate length. Soybeans are also susceptible to powdery mildew, but this will cause yield reduction only if it occurs in July.

Harvesting/Storage

Direct-combine when the pods are dry and the seeds are hard. Combining can take place when seed moisture is below 20 per cent, but soybean must be stored at less than 14 per cent. Seed damage is high when soybean is harvested at less than 12 per cent moisture, and harvest losses can also be high under dry conditions (four beans per square foot represents a harvest loss of 60 lb/acre, so caution is advised). A floating cutterbar is ideal to minimize harvest losses. Careful adjustment of cylinder speed and concave clearance are needed to minimize cracking and splitting of seed.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomi characteristics, refer to the current *Seed Manitoba*.

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BUCKWHEAT

Field Selection

Buckwheat grows well on light to medium-textured soils. Weed control options in buckwheat are limited, and therefore best yields will be obtained from clean fields. Avoid fields that contain very high levels of nitrogen fertilizer, since this can cause crop lodging.

Seeding

Treatments

Buckwheat is sown late, when soil temperatures are high, and seedlings will emerge quickly. Seedling diseases are not common. There are no registered seed treatments.

Dates

June 1 to June 20. Buckwheat is very susceptible to frost in late spring or early fall. To maximize yields, buckwheat should be sown early in June after the risk of frost.

Rates

36-48 lb/acre to achieve a plant stand of 13-17 plants/ft^2. See page 7 for calculating optimum seeding rates using plant populations. New varieties tend to have larger seed size, along with increased bushel weights. These large-seeded varieties have larger leaves, and as a result do not require higher seeding rates than the smaller-seeded types.

Depth

1 to 2.5 inches. Seed should be placed only deep enough to reach moisture to obtain rapid and uniform emergence.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested. Buckwheat requires less fertilizer than cereal crops and is very efficient at removing phosphorus from the soil.

If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-20 lb/acre N following fallow or legume breaking, 20-40 lb/acre N following grass and grass-legume breaking and 40-60 lb/acre N following stubble. The primary nitrogen deficiency symptoms are yellow leaves and stunting.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre in a sideband or 20 lb/acre with the seed.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre.

Sulphur (S): Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to determine the available sulphur status of fields. Apply sulphate sulphur at 15 lb/acre when required.

Special considerations: Buckwheat grown under high-nitrogen conditions is more prone to lodging. Buckwheat is also known to use phosphate from the soil and make it available for subsequent crops through stubble decay.

Weeds

Weed control in buckwheat can be difficult and requires planning, since there are few herbicides available, particularly for broadleaf weed control. Since buckwheat is sown late, there is ample opportunity to control problem weeds with herbicides or cultivation before seeding. Do not use herbicides that may leave a residue before seeding. Weeds can reduce both yield and quality of buckwheat. Seeds that constitute foreign matter include wheat, rye, barley, oats, triticale, peas, beans and corn, as well as several weed seeds.

Insects

Grasshoppers and cutworms can damage buckwheat.

Diseases

Buckwheat is free from most diseases that affect other broadleaved crops. Three diseases that do affect the crop are Botrytis leaf and stem rot, downy mildew and Rhizoctonia root rot.

Pollination

Buckwheat benefits from pollination. Bee visits to buckwheat in the early stages of flowering (first two weeks of July) will benefit yields.

Harvesting

Swathing

Much of the yield is determined by seed development in the primary seed cluster. Buckwheat should be swathed when about 75-80 per cent of the seeds have turned brown or black. The best way to determine this is to pull a few plants and turn them over and judge seed turn. Yield increases rapidly in the last two of weeks of growth, and therefore swathing should be delayed as long as possible. Usually the crop will show marginal shattering before swathing, but the amount of shattering is minimal, compared with the increases at this stage of growth.

If a light frost occurs (top third of crop canopy or less), the yields of the crop will be further improved, since all flowering will be stopped. If a hard frost occurs (more than the top third of canopy), swathing should begin immediately. Shattering losses can be minimized by swathing when the crop is damp and by matching reel speed with ground speed.

Desiccation

Desiccation weakens the stem and causes lodging. Do not desiccate buckwheat.

Timing

Standing buckwheat is difficult to manage after the crop has been exposed to frost. Where possible, try to swath the crop before a heavy frost.

Combining

To minimize shattering, ensure that the pickup speed equals ground speed. Combine adjustments are important to minimize the dehulling of seed; therefore, use a cylinder speed of 600-800 rpm, concave of 1/2 to 5/8" at front and 1/4" at rear. If seed is dehulling, increase concave size or lower cylinder speed.

Storage

A moisture content of 16 per cent or less is necessary for safe storage of buckwheat. The primary market for buckwheat is Japan, which buys only new crop seed; therefore, it is important not to mix old and new crops. These mixtures of old and new seed are easily detected, as the old seed oxidizes and the light green layer just under the hull in new seed gradually changes to reddish brown during storage.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

CANARY SEED

Field Selection

Canary seed grows well on clay or clay loam soils, provided surface drainage is good. Canary seed is sensitive to a number of herbicide residues.

Certain herbicides are residual in soil to varying degrees and under a range of field conditions. Examples include:

	Group
atrazine (Atrazine)	5
clopyralid (Lontrel, Curtail)	4
ethalfluralin (Edge)	3
ethametsulfuron (Muster)	2
flucarbazone (Everest)	2
imazethapyr (Pursuit, Odyssey)	2
metsulfuron methyl (Ally)	2
sulfosulfuron (Sundance)	2
trifluralin (Treflan, Rival)	3

To determine the factors affecting the persistence of each product and for specific recropping intervals, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.

Seeding

Treatments

There are no registered seed treatments for use on canary seed.

Dates

Canary seed should be seeded early in the growing season. A long growing season is required to optimize yield. Days to maturity are greater than wheat, at approximately 105 days.

Seeding Rates

35-45 lb/acre to achieve a plant stand of 40-55 plants/ft^2. See page 7 for calculating optimum seeding rates using plant populations. Higher rates will provide greater weed control and will be helpful if the seed is being planted greater than two inches deep.

Depth

1 to 2 inches.

Fertilizer

For specific recommendations, have your soil tested. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-55 lb/acre N following grass and grass-legume breaking and 55-90 lb/acre N following stubble.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre.

Potassium (K_2O): On sandy-textured or organic soils, apply potassium at rates of 15-30 lb/acre.

Sulphur (N): Low sulphur levels can occur in any Manitoba soils. When required, apply 15 lb/acre of sulphate sulphur.

Weeds

Canary seed plants do not compete well with weeds during the establishment period. Chemical options are limited, but include both grassy and broadleaf weed products.

Insects

Aphids can damage canary seed. Economic thresholds for spraying are when there are at least 10 to 20 aphids on 50% of the stems prior to the soft dough stage. Aphids will often hide along the stem inside the canaryseed head. When counting aphids on canaryseed, the head should be bent and closely inspected, along with inspecting other parts of the plant, to properly determine infestation levels.

Diseases

Few disease problems have been reported in Manitoba. Septoria leaf mottle, a residue-borne disease, has been reported in Saskatchewan. A crop rotation with at least a two-year break from canary seed is the best way to manage the disease, as no fungicides are currently registered for the control of the disease.

Harvesting

Swathing

Although current varieties of canary seed will lodge, the crop is very resistant to shattering. Direct harvesting is recommended.

Combining

Use cylinder speed of 600-750 rpm. This will thresh the seed out of the compact head, but minimize the amount of dehulling. The hull needs to be left on the seed, as it gives the seed its shiny appearance. Set concave clearance at 3/16-3/8 inch in the front and 1/8-3/16 inch in the rear. Use less wind than with wheat, but enough to lift the chaff. Reduce the return of seed to the cylinder to prevent further cracking or dehulling of the seed. It is better to have a somewhat dirty sample than a dehulled sample.

Storage and Handling

Canary seed can safely be stored at 12 per cent.

Grade

Canary seed does not fall under a grade standard. Visual appearance is important. It is usually sold as 99 per cent pure seed, with no more than 4 per cent dehulled seeds.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomi characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

CHICKPEA

Chickpea is one of the most widely produced pulse crops throughout the world. The small-seeded desi type is used primarily in the forms of splits or flour. The large-seeded kabuli or gàrbanzo type is used for canning and salad bars. A yield of 25-30 bu/acre is realistic.

Field Selection and Seeding:

Chickpea is a cool-season pulse suited to the driest parts of Manitoba. Chickpea matures in 110 days. Seedlings tolerate frost. Chickpeas are best-suited to well drained soils. Seed in late April to early May at 50 lb/acre for desi-type to 1.5 inches deep.

Management:

Inoculate with appropriate *Rhizobium* strain. Fertilize as for field peas. No herbicides are registered. Chickpea is not competitive. Disease concerns include ascochyta blight, for which tolerant varieties are available, and sclerotinia and botrytis. These diseases affect both yield and quality. To minimize risk, use disease-free seed, seed treatment, or tolerant varieties, adequate rotation and wide row production. Foliar fungicide may be used but, because the disease develops rapidly, frequent scouting, to catch the initial appearance of ascochyta, is critical.

Harvest:

Swath and combine, or direct-combine when all pods are yellow. Store at less than 13 per cent moisture. Ideal quality is sound, whole, clean seed.

BIENNIAL CARAWAY

Biennial caraway is most commonly produced in Manitoba. Annual-type caraway is available but is considered too late-maturing for Manitoba. Biennial caraway may produce a second harvest in year three, from plants that did not flower in year two. Yields can range from 700 to 1,000 lb/acre. Yields up to 1,700 lb/acre have been reported.

Seeding

Dates

Biennial caraway is seeded with a nurse crop in late April to mid May. Caraway is slow to germinate and emerge.

Rates

Seeding rate is 10 to 12 lb/acre. The nurse crop should be sown at 1/2 normal seeding rate. Seed weight/bulk density is approximately 35 to 40 lb/bu.

Depth

0.5 to 1 inch in a firm, moist seed bed.

Fertilizer

Fertilizer trials have not been conducted in Western Canada. Suggested guidelines:

Nitrogen (N): Fertilizer according to the need of the nurse crop in year one. Broadcast 55 to 60 lb/acre in the spring of year two (and year three if applicable). Tolerance of seed-placed N is not known, so it is not recommended.

Phosphate (P_2O_5): Band for the nurse crop and second-year caraway before seeding. Requirements are similar to cereals: 20-40 lb/acre, 20 lb/acre maximum in seed row.

Potassium (K_2O): Requirements are similar to cereals: 15 to 30 lb/acre where required.

Sulphur (S): Requirements similar to cereals: 15 to 30 lb/acre where required.

Weeds

Caraway is a poor competitor with weeds. Perennial weeds (thistles, dandelions) and winter annuals (stinkweed, flixweed) are difficult to control. Weeds cause yield losses and excessive dockage losses. Few products are registered for weed control.

Insects

Grasshoppers and leafhoppers can damage caraway. Grasshopper heads and parts in the harvested crop can result in downgrading. Leafhoppers can spread aster yellows.

Diseases

Damping-off and root rot cause yellowing and death of emerging seedlings in year one. In year two, affected plants have slow development, stunting, yellowing at the flowering state and a poor seed set.

Phoma blight is seed-borne, affecting the stem and head with raised grey to black lesions.

Aster yellows is a disease carried plant-to-plant by leafhoppers. Infected plants at flowering time have their flowers turn yellow and grow tattered. Plants do not set seed.

Pollination

Yield increases have been reported with the use of honeybees for pollination.

Harvesting

Swath when approximately 75 per cent of the seeds turn brown. Swathing too early results in shrivelled, immature seed. Shattering occurs if swathed too late. Thresh when seeds are all light brown with dark valleys between lighter ridges. Caraway threshes easily with settings similar to canola and mustard.

Storage

Store at less than 10 per cent moisture. Hot air drying is not recommended. Moisture-metre charts are not available. Limited information suggests the canola chart is comparable.

Quality

Downgrading or rejection can result from insect parts, rodent droppings, weed seeds, other foreign material and overly dark colour. Cleanouts of 15 to 20 per cent are typical. Quality is judged according to aroma and colour. Colour is preserved by ensuring the crop is not in the swath too long. Aroma is preserved by proper curing and storage.

CORIANDER

There are large-seeded (3-5 mm) and small-seeded (less than 3 mm) available. Typical yields range from 800-1,000 lb/acre. Yields up to 2,500 lb/acre have been reported. Leaves may be harvested as cilantro.

Seeding

Dates

Coriander is seeded in late April to mid-May. Coriander is slow to germinate and emerge.

Rates

Seeding rate is 18-20 lb/acre for both types. It may be necessary to increase the seeding rate to 30-40 lb/acre to get a good stand of the large-seeded type.

Split seed can be sown at half the rate with no significant yield reduction, provided germination tests greater than 80 per cent. If split seed from screenings is used, there is a risk of sowing weed seeds, which may also be found in the screenings; therefore caution is advised.

Depth

1 inch deep in a firm, moist seed bed.

Fertilizer

Fertilizer trials have not been conducted in Western Canada. Suggested guidelines:

Nitrogen (N): Moderate N (50-60 lb/acre) is required. No more than 30 lb/acre for the small seeded type as it is taller and later maturing. Tolerance of seed-placed N is not known, therefore is not recommended.

Phosphate (P_2O_5): Requirement similar to cereals: 20-40 lb/acre. Band 20 lb/acre under good, soil moisture condition. Tolerance of seed-placed phosphate is not known and therefore is not recommended.

Potassium (K_2O): Requirements similar to cereals: 15-30 lb/acre. Band prior to seeding on deficient soils.

Sulphur (S): Requirements similar to cereals: 10-15 lb/acre. Band prior to seeding on deficient soils.

Weeds

Coriander is a poor competitor, especially with perennial weeds. Ensure that perennial weeds are under control before sowing. Weeds can cause yield loss and excessive dockage losses. Few herbicides are registered. Contact Manitoba Agriculture and Food for more information.

Insects

Grasshoppers and leafhoppers can damage coriander. Grasshopper heads and parts in the harvested crop can result in downgrading. Leafhoppers can spread aster yellows disease.

Diseases

Damping off and root rot cause yellowing and death of emerging seedlings.

Aster yellows is a disease carried by leafhoppers. Infected plants become evident at flowering time, when their flowers turn yellow and they often grow taller than uninfected plants. Plants do not set seed.

Sooty mold is a fungal disease that can affect stems and seed damaged by hail or heavy rain.

Pollination

Yield increases with honeybees for pollination have been reported.

Harvesting

Swath when the seed is tan to brown in colour. Since the swath is prone to wind damage, direct combining has also been successful. Thresh when moisture is below 15 per cent. Threshing when the seed is very dry can lead to excessive splitting. Swathing or threshing in damp weather or when the crop is tough with dew may help to minimize both shattering losses and splitting.

Storage

Store at less than 10 per cent moisture, with green material removed as soon as possible. The seed "cures" in early storage and aeration assists this process. Hot-air drying is not recommended. Since a moisture chart for coriander is not available, use the sunflower chart.

Quality

Downgrading or rejection can result from insect parts, rodent droppings, weed seeds, other foreign material, overly dark colour or splits greater than 5 per cent. Cleanouts of 15-20 per cent are typical. Buyers judge quality according to aroma, colour and purity. Colour is preserved by ensuring the crop does not lie in the swath for too long. The aroma is preserved by proper curing and storage.

CORN

Corn can be a profitable option in the warmer areas of Manitoba. Corn growth and yield depends on the amount of heat accumulated during the growing season, as measured by Corn Heat Unit (CHU). Figure 4 shows minimum CHU accumulated across the province, nine years out of 10.

Field Selection

Corn generally performs best on well-drained, sandy or sandy loam soils. Warm spring soil is important for rapid early season growth. Corn is sensitive to trifluralin and Muster residues applied to preceding crops. Consult product label or Manitoba Agriculture and Food *Guide to Crop Protection* for details.

Seeding

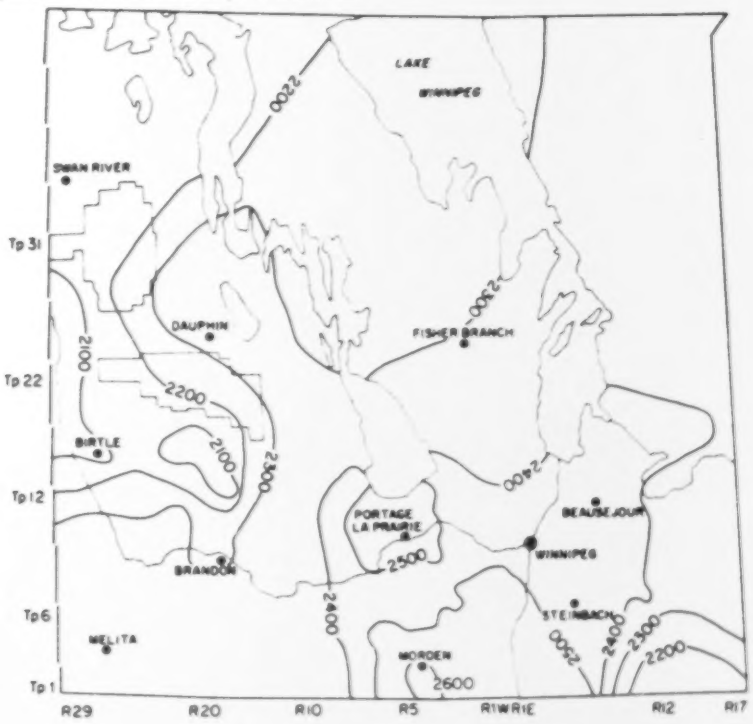
Date

Ideally, corn should be seeded between May 1 and May 15. Earlier planting when possible is acceptable, as emerged corn recovers readily from frost injury. Corn will not germinate until soil temperature is above 10° C. When seeded late, yield potential is reduced significantly, and risk of crop failure increases.

Hybrid Selection

In order to select the best hybrid, the corn heat unit (CHU) rating of the farm, the CHU rating of the hybrid, and whether the hybrid will be grown for grain or silage must be known.

Figure 4 - Corn heat unit map for Manitoba



Once the heat unit rating for a farm has been established, the producer should select hybrids requiring 200 CHU less than the CHU expected. This will ensure that corn planted by mid-May will reach full maturity before a killing frost, 9 years out of 10. If planting is delayed beyond mid-May, the estimate of the number of heat units available should be reduced by 100 for each week that planting is delayed.

The silage hybrid can have a rating of 200 CHU greater than that for a grain corn hybrid selected for the same farm. Selecting a very long season hybrid results in low-quality silage.

Seeding

Rate

Grain

- 22,000-24,000 plants/acre or 0.6 plants/ft^2 under ideal conditions
- 18,000-22,000 plants/acre under reduced yield conditions

Silage

- 22,000-28,000 plants/acre or 0.7 plants/ft^2.

See page 7 for calculating seeding rate using plant populations. Higher plant populations will increase yield potential under ideal conditions. High plant populations are beneficial in the warmest areas of the province when seeding early on fertile, well-drained soils. Lower populations should be used when seeding is delayed, and where risk of moisture stress is greater.

Table 14. Corn seeds required per m (39") of row for various populations

(Assuming 85 per cent plant survival)

Population (plants/acre)	30" row spacing	36" row spacing
	Seeds per 39" row (one metre)	
18,000	4.0	4.8
20,000	4.4	5.3
22,000	4.8	5.8
24,000	5.3	6.3
26,000	5.7	6.8
28,000	6.2	7.3

Depth

1.5 to 3 inches; to moisture. Seeding too shallow increases risk of damage from rodents and birds. Under very dry seed bed conditions on sandy soils, deeper seeding may be required.

Fertilizer

For specific recommendations, have your soil tested. Take samples at depths of 0-6 inches and 6-24 inches. If soil analyses are not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-65 lb/acre N following grass and grass-legume breaking and 65-135 lb/acre N following stubble.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre.

Potassium (K_2O): On sandy-textured or organic soils, apply potassium at rates of 30-100 lb/acre.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to determine the available sulphur status of fields.

Special considerations: Most Manitoba soils contain sufficient micronutrients for corn production. Zinc may be marginally deficient on high lime soils. Deficient plants show yellow to white-bleached bands in the lower part of emerging leaves. Use plant tissue analysis and soil testing to confirm deficiency.

Weeds

Weeds in corn may be controlled by two basic methods, cultural or chemical, or by a combination of both. Inter-row cultivation is commonly used to supplement chemical weed control. Cultivation can begin when crop rows are visible. Use shields and reduce speed to ensure that the corn seedlings are not covered. Root pruning can be a problem when cultivating larger plants. Chemical control involves the use of various registered herbicides singly or in combination. Cultural plus chemical control includes the use of inter-row tillage equipment combined with herbicide application only to the rows.

Insects

European corn borer is the most common insect in corn. Damage includes stalk breakage, ear drop and yield loss due to reduced sugar movement.

Harvesting

Grain

Corn harvest for grain can begin when kernel moisture reaches 30 per cent; however, drying costs will be relatively high. Harvesting losses will increase as kernel moisture drops below 25 per cent.

Grain Storage Moisture

Dry to a minimum of 18 per cent. For long-term storage, corn should be dried to 13 per cent moisture. Corn to be used for distilling should be dried to 14.5 per cent.

Silage

Cut when whole-plant moisture is 65-70 per cent. For high-producing dairy cows, timely cutting is important to maximize milk production. Cut at 70 per cent moisture or, in the case of a large upright silo, as low as 62 per cent to minimize seepage. As a rule, this occurs when kernels are well dented and beginning to glaze, and the milkiness is at 1/2 to 2/3. Cutting too early results in excessive freezing and "running" (loss of liquid). Cutting too late increases spoilage.

Diseases

Planting disease-resistant varieties, using proper crop rotation will help to minimize disease problems.

Brief descriptions of the more common diseases seen in corn are provided in the *Corn Production in Manitoba* guide, available at Manitoba Agriculture and Food.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

MUSTARD (YELLOW, ORIENTAL AND BROWN)

Field Selection

Mustard can be grown on most soil types and is best adapted to the Brown and Dark Brown soils. Soils prone to crusting and dry, sandy soils are not recommended. Yellow, brown and Oriental mustard tolerate drought conditions. Fields should be free of wild mustard and volunteer oilseed crops.

Seeding

Treatments

Mustard seed can be treated to minimize losses from damping-off and root rot. Seed is also frequently treated for control of flea beetles when they are forecast to be a problem.

Dates

May 5 to May 31. Seedlings are quite tolerant of frost; therefore, to maximize yields, sow early in May.

Rates

Yellow Mustard — 7-10 lb/acre to achieve a plant population of 7-11 plants/ft^2 (70-110 plants/m^2)

Brown and Oriental Mustard — 4-6 lb/acre to achieve a plant population of 7-11 plants/ft^2 (70-110 plants/m^2)

Seeding rates at the high end of the recommended range should be used for late seeding, soil prone to crusting or heavy weed pressure. See page 7 for calculating seed rates using plant populations.

Depth

0.5 to 1.5 inches. Seed should be placed only deep enough to reach moisture.

Fertilizer

General

For specific recommendations on fertilizer rates, have your soil tested. Mustard is similar to canola in sensitivity to high rates of seed-placed fertilizer. Refer to tables 3 and 4 for maximum safe rates of N and P. All potassium and sulphur should be applied away from the seed. If soil analysis is not available, a general recommendation is as follows:

Nitrogen (N): Apply 0-30 lb/acre N following fallow or legume breaking, 30-70 lb/acre N following grass and grass-legume breaking and 70-90 lb/acre N following stubble. High-yielding mustard requires high nitrogen fertility. The primary nitrogen deficiency symptoms are yellowing, starting with the older leaves, and thin, spindly stems.

Phosphate (P_2O_5): Apply phosphate at 30-40 lb/acre as a sideband or 20 lb/acre with the seed. The primary phosphate deficiency symptom is poor root development and reduced branching with thin, spindly branches.

Potassium (K_2O): On sandy textured or organic soils, apply potassium at rates of 30-60 lb/acre. Deficiency symptoms are stunted growth, with smaller leaves and thinner stems. Eventually the edges of lower leaves turn brown and drop off.

Sulphur (S): Apply sulphate sulphur at 20 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to determine the available sulphur status of fields. Mustard requires about twice as much sulphur as do cereal crops. A minor sulphur deficiency is usually not detected visually, but results in significant yield reductions. Major sulphur deficiency symptoms are most visible on the newest leaves and start with yellowing. Leaves showing more severe deficiency symptoms may be cup-shaped, with purple colouration on the back of the leaves.

Weeds

Weeds can reduce both yield and quality of mustard. Some of the weed seeds that are difficult to remove or cannot be cleaned out of yellow mustard and cause downgrading are wild mustard, cow cockle, volunteer canola, ball mustard, dog mustard and stinkweed. Weed seeds causing downgrading for brown or oriental mustard are cow cockle, pigweed, volunteer canola, cleavers and wild mustard.

Insects

Grasshoppers, cutworms, bertha armyworm, flea beetles and diamondback moth can damage mustard.

Diseases

Mustard is susceptible to sclerotinia, and therefore crop rotations that include field beans, field peas, canola, sunflowers and other sclerotinia-susceptible crops increase the risk of infection of the mustard crop. All types of mustard are resistant to blackleg.

Harvesting

Desiccation

Desiccation accelerates plant dry-down, not plant maturity, and therefore should not be sprayed before the stages indicated for swathing. For detailed information on desiccation, consult the current *Guide to Crop Protection*.

Swathing

Yellow mustard is resistant to shattering and therefore can be straight-combined. If the crop is to be swathed, seed moisture should be around 25 per cent.

Brown and oriental mustard are less resistant to shattering and are usually swathed. In order to minimize shattering, swath under dewy conditions.

Brown mustard should be swathed when 60 per cent of the seeds are reddish-brown. Seeds that are green at this stage will not mature in the swath.

Oriental mustard should be swathed when 75 per cent of the seeds are yellow. Seeds that are green will not mature in the swath.

Combining

Mustard is considered ready to combine when moisture reaches 12-13 per cent or less and no green seed can be found. Pickup speed should match ground speed to minimize shattering losses. Cylinder speed should be about 500-600 rpm; if the cylinder speed is too fast, seeds will crack. Wind speed should be kept low in order to minimize seed loss with the chaff.

Straw Management

Mustard straw breaks down quite readily and can be toxic to flax the following year. In order to minimize seeding problems in the spring, the straw should be spread behind the combine rather than placed in a row.

Storage

For long-term storage, mustard should be at 9 per cent moisture. Mustard stores best at temperatures below 20° C.

Once in storage, mustard should be cooled, since the seed continues a high respiration rate for up to six weeks. This respiration rate creates moist areas (sweating) in the bin that become hot spots. Mustard should be monitored carefully for heating problems.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

FORAGE ESTABLISHMENT

Field Selection

Soils

Suitable forage species are available for all types of Manitoba soils and moisture conditions. Use Tables 16 and 17 as a guide for selecting hay and pasture forages for different soil conditions.

Weeds

Perennial weeds are difficult to control in seedling forages, and should be controlled before establishment.

Seed Bed Preparation

If conventional tillage practices are being used, prepare a fine, firm, shallow seed bed.

Increasingly, forage growers are successfully establishing forage stands without tillage. Benefits of zero-tillage forage establishment are:

- lower costs and less labour;
- better seed bed moisture conservation;
- standing "dead mulch" protects an emerging crop from drying-out and sandblasting.

Seeding

Inoculation

Treating legume seeds with an appropriate inoculant ensures good nitrogen (N) fixation, and should be carried out before seeding. Inoculant contains living rhizobium bacteria, and must be handled carefully to ensure viability. Keep inoculant in the sealed original container, store in a refrigerator until required and do not expose to direct sunlight. Plant immediately after inoculation. If seeding is interrupted, store seed in a cool, dark place and resume seeding when possible.

Pre-inoculated seed is also available. Store seed in a cool, dark place to keep the inoculant viable.

Each legume or group of legumes requires a specific species of *Rhizobium* bacteria for N fixation. Ensure that the inoculant you buy is appropriate for the crop being seeded.

Alfalfa group	–alfalfa and sweet clover
Clover group	–for red clover, white clover and alsike clover
Birdsfoot Trefoil	–birdsfoot trefoil only
Sainfoin	–Sainfoin only

Seed Coating

Grasses, which are very light in weight, are difficult to seed. To improve the seed flow characteristics, these seeds are frequently encased within a coating of heavier material. This material is usually an inert substance, such as clay, mixed with some fertilizer to promote rapid establishment of the stand. When using coated seed, it is important to adjust the seeding rate to account for the coating.

Time of Seeding

Spring Seeding

The best time to seed forages is in the early spring, as soon as field conditions permit. The cool, moist conditions of early spring are most favourable for the germination and growth of both grasses and legumes. The moist conditions also allow for a shallow seeding depth, which is very important for quick establishment of the forage crop.

Summer Seeding

If there is adequate moisture, forages can be seeded from late July to mid-August. During this period, only grasses should be seeded. The legumes require a longer growing period to ensure winter survival.

Dormant Fall Seeding

Dormant seeding can be attempted when the soil temperatures approach the freezing point and germination is unlikely. The seed germinates in the spring when the growing conditions will be close to ideal. However, an early snowfall can raise the soil temperatures sufficiently to cause the seed to germinate in the fall and die over winter. Use dormant seeding in problem areas that are not suitable for seeding in the spring and summer.

Seeding Equipment

Disc Drills

Disc drills will work well, provided the seed is not placed too deep. Use depth-control bands mounted on discs, or release down-pressure from discs to let them float on a soil surface. Another option is to remove downspouts and drop seed in front of discs or hoes, allowing soil thrown up by the openers to cover the seed. Alternatively, seed tubes can be moved back to drop seed behind the openers, in front of the press wheels.

Discer Seeders

Discer seeders are not recommended for seeding forages, as they generally seed too deep.

Broadcast Seeding

Broadcast seeding is satisfactory when seed is spread uniformly and packed properly. Spinner spreaders do not spread seed uniformly, especially when a seed mixture is used. Valmar or other air flow-systems offer more uniform distribution.

Sod Seeding Drills

There are several brands of drills available that are designed to seed into an existing sod. Both hoe and disc type drills work well. The key is shallow, uniform seeding.

Drum Seeders

Drum seeders work well where stones are a problem. Forage seed is metered from a seed box in front of a large roller, which when weighted with water will pack down stones and firm the seed bed.

Seed Metering

If seed box agitation is not available, many forage grasses will bridge over seed cups, causing skips. To reduce bridging, do not fill seed box above half full. Alternatively, mix seed with cracked wheat (one part cracked wheat; two parts grass seed). Some growers are successfully using phosphate fertilizer as a carrier. If this is done, ensure that seeding takes place immediately after mixing with the fertilizer. Where drills or airflow devices have a countershaft over the seed cups, placing pipe clamps on the countershaft will improve seed flow.

Pack the seed bed after seeding, especially when broadcast seeding, to ensure good seed-to-soil contact, and to bring moisture to the soil surface. Use a harrow packer, harrow or roller.

Seeding Depth

Seed shallow (1/4 to 1 inch) into a firm seed bed. Seed at 1/4 inch for small-seeded forages, such as timothy, on heavy soils. Seed deeper for large-seeded forages, such as intermediate wheatgrass or alfalfa, on lighter soils.

Seeding Rates

Refer to Tables 16 and 17 for hay and pasture seeding mixes.

Refer to Table 15 for seeding rates and to page 7 for detailed instructions on seeder calibration.

Companion Crops

Cover crops compete severely with the forage crop for light, moisture and nutrients, reducing winter survival and yield the following year. However, they are often used to reduce weed competition, sand-blasting and desiccation. If they are used, reduce seeding rate and nitrogen rates by half, and harvest as green feed if possible to reduce competition.

Table 15. Hay and pasture seed calibration table.

Crop	Seeds/lb (000's)	Number of seeds/yd of Row at 1 lb/acre			Seeding Rate for Pure Forage Stands lb/acre
		Row Spacing			
		6-inch	8-inch	12-inch	
Alfalfa	200	6	8	13	8
Alsike Clover	700	21	28	42	3
Red Clover	275	8	11	17	8
White Clover	800	23	33	50	3
Sweet Clover	260	8	10	16	8
Birdsfoot Trefoil	375	11	16	23	4
Meadow Bromegrass	80	2	3	4	8
Smooth Bromegrass	136	4	6	8	6
Intermediate Wheatgrass	88	3	4	6	8
Slender Wheatgrass	160	5	7	10	6
Tall Wheatgrass	80	2	3	4	8
Crested Wheatgrass	190	5	7	11	8
Meadow Fescue	230	7	10	14	8
Tall Fescue	227	7	10	14	8
Creeping Red Fescue	615	18	25	37	6
Meadow Foxtail	577	17	24	36	6
Creeping Foxtail	753	23	31	47	5
Orchard Grass	650	20	27	39	6
Timothy	1,230	37	50	73	2
Reed Canary	530	16	22	33	6

Table 16. Hay crop seeding mixtures for different soil moistures.

Seeding Rates (lb/acre) at different soil moistures												
Forage Species	**— Dry →**		**—— Ideal ——→**				**—— Wet ——→**				**Saline**	
Alfalfa	6	6	8	6	6	6					3	3
Alsike Clover							3	2				
Red Clover									3			
Sweet Clover											3	3
Smooth Bromegrass	4											
Meadow Bromegrass				4								
Intermediate Wheatgrass		4				4						
Orchard Grass					3							
Timothy			2	2	2		2	2	2	2		
Crested Wheatgrass												
Reed Canary								4	4	3		
Slender Wheatgrass											5	
Tall Wheatgrass											5	
Tall Fescue										5		5
Total (lb/Acre)	10	10	10	12	11	10	5	8	9	10	16	11

Table 17. Pasture seeding mixtures for different soil moistures.

Seeding Rates (lb/acre) at different soil moistures												
Forage Species	**—— Dry ——→**				**—— Ideal ——→**				**—— Wet ——→**		**Saline**	
Alfalfa	2	2	2	2	1	1	1	1		1	2	1
Alsike Clover									1		1	
Birdsfoot Trefoil					1	1	1	1	1	1	2	1
Sweet Clover											2	2
Meadow Bromegrass			8		6		5	4				
Smooth Bromegrass		6										
Orchard Grass						6						
Tall Fescue							3					4
Creeping Red Fescue								4		6		
Timothy					2	2			2	2	2	
Tall Wheatgrass	2	2										
Intermediate Wheatgrass				8								
Slender Wheatgrass											2	2
Crested Wheatgrass	7											
Meadow Foxtail									4			
Creeping Foxtail											4	4	2
Reed Canary											3		
Total (lb/acre)	9	8	10	10	9	10	10	10	8	10	10	14	14

Fertilizer

For specific recommendations, have your soil tested. Sample soil at 0-6 inches and 6-24 inch depths before establishment or on established stands. Sampling to 0-6" is useful only on established stands where sulphur levels are known to be sufficient.

When establishing forages, phosphorus fertilizer is applied most effectively by banding one inch to the side and one inch below the seed. If phosphorus cannot be banded, incorporate it and all other fertilizer into the soil before seeding.

Fertilizing grass stands

Annual broadcast applications of phosphorus, potassium and sulphur fertilizer on established grass crops may be made in late fall or early spring. Do not apply fertilizer to frozen soils subject to water runoff. Rate of nitrogen fertilization can be based on soil test levels or value of the crop and cost of fertilizer (refer to Manitoba Agriculture and Food fact sheet *Economics of Grass Hay Fertilization*).

General Recommendations:

Nitrogen (N): At time of establishment, apply 0-20 lb/acre N following fallow, 40-60 lb/acre N following stubble. Apply 90-110 lb/acre N to established stands when forage price is high and soils are moist.

Phosphate (P_2O_5): Apply 25-40 lb/acre at time of establishment and 20-30 lb/acre for established stands.

Potassium (K_2O): On sandy-textured or organic soils, apply 45-90 lb/acre at time of establishment or 30-60 lb/acre to established stands.

Sulphur (S): Apply sulphate sulphur at 15 lb/acre on well-drained soils and grey luvisol (grey wooded) soils.

Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to establish the available sulphur status of fields.

Sources of Nitrogen

Ammonium nitrate is generally 10-15% more efficient than urea in increasing the yield of the first cut of grasses. Manitoba studies have found that under conditions of minimal volatilization loss, urea forms are equal to or superior to ammonium nitrate for fertilizing late season grasses in multiple harvest systems and grass pasture. In these instances, hay or pasture grasses fertilized with urea can have higher crude protein levels than those fertilized with ammonium nitrate.

Volatilization losses of surface applied N may be very high if rainfall is not received soon after application. Volatilization losses are greatest when urea is applied to a moist thatch cover, followed by warm, windy weather.

Performance of N solutions are improved by surface band or dribble application. Treating urea with an urease inhibitor will delay volatilization losses for up to 14 days.

Broadcast N solutions are not satisfactory for established forages. To increase efficiency of nitrogen application with N solutions, they should be surface or dribble banded or injected into the soil with equipment such as a spoke wheel applicator.

Time of application

Grass for Hay or Pastures - The relative efficiency of broadcasting granular nitrogen fertilizer on established grass is as follows:

- Spring application
  April to mid-May—100 per cent
- Fall application
  October —78 per cent

Split-rate nitrogen applications (applying one-half the required N in the spring and the other half immediately after the first cut) is comparable to a single spring application.

The split-rate technique has the added advantage of equalizing the production of forage with a relatively higher protein content throughout the growing season. It is also useful for pasture production where rotational grazing is practised. Split application of less than 45 lb/acre N is not recommended.

Fertilizing legumes

Annual applications of fertilizer on established legume crops may be in the fall or early spring. Do not apply to frozen soils subject to water runoff. Additional information is contained in the Manitoba Agriculture and Food fact sheet *Fertilizing Alfalfa Forage*.

General Recommendations:

Nitrogen (N): Nitrogen is not recommended. Inoculate legume seed before planting.

Phosphate (P_2O_5): Apply 55-75 lb/acre at time of establishment and 45-55 lb/acre for established stands.

Potassium (K_2O): On sandy textured or organic soils apply at 55-150 lb/acre at time of establishment or 40-100 lb/acre for established stands.

Sulphur (S): Apply sulphate sulphur at 30 lb/acre on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. A soil test is recommended to determine the available sulphur status of fields.

Micronutrients

The micronutrient boron is particularly important for alfalfa. Visual deficiencies appear as yellowing to reddening of the youngest upper leaves on the plant. Deficiencies are generally limited to high pH, sandy soils when plants are under drought stress. Since deficiencies are often weather-related, they may be observed one year and not the next. Confirm deficiencies with soil and plant-tissue analysis. Where boron-deficiency is confirmed, broadcast apply 1-2 lb boron/acre. Apply with caution, since excessive boron can cause toxicity in following crops such as oats and beans.

Fertilizing mixtures of grasses and legumes

Stands that are more than 50% legume do not require nitrogen fertilizers. For stands that are less than 30% legume, responses to nitrogen fertilizer can be expected as for a pure grass stand. Where conditions permit, it is generally more profitable to re-seed mixtures containing legumes.

Diseases

Leaf diseases are the most commonly encountered and obvious disease problem with the forage grasses. If the incidence of leaf disease becomes severe, rotate the field to other crops for several years.

Ergot can be a serious problem on bromegrass and wheat grasses. Mowing the grass at heading time will prevent the formation of ergot bodies in the developing florets. This also stops the spread to nearby fields of rye, triticale, wheat or barley. After breaking up a seed field where ergot has been a problem, avoid rye, triticale, wheat or barley for one year.

Forage legumes are susceptible to a number of leaf spot diseases. They are also affected by root and crown rots, which may be associated with winter injury. Foliage diseases overwinter on infected stubble and may build up to become a severe problem. Cut before leaf drop to minimize leaf loss and reduce the amount of overwintering disease. Take severely infected fields out of production. Early-spring burning before new growth may also reduce leaf and stem diseases. Rotate with cereals or corn for at least one year before replanting to a forage legume.

Alfalfa and sweet clover are susceptible to verticillium wilt. Avoid potatoes and sunflowers in the rotation because of common susceptibility to verticillium wilt.

For more information, consult Manitoba Agriculture and Food *Field Scouting Guide* and the current *Guide to Crop Protection*.

For specific information on:

- **seed treatments**, refer to the current Manitoba Agriculture and Food *Guide to Crop Protection*.
- **integrated management** of **weeds**, **crop pests** and **diseases**, refer to Manitoba Agriculture and Food's *Field Scouting Guide*.
- **pesticides**, refer to the current *Guide to Crop Protection*.
- **optimizing fertilizer use**, refer to Manitoba Agriculture and Food's *Soil Fertility Guide*.
- making **varietal choices** based on agronomic characteristics, refer to the current *Seed Manitoba*.

These and other Manitoba Agriculture and Food publications are available from your local extension office or online at **www.gov.mb.ca/agriculture/** under the headings of Crops & Plants, Soil & Conservation, and Weed, Insect & Disease. Your local agricultural representative can help you find those resources most relevant to your needs.

Harvesting and Storage of Quality Hay and Silage

Introduction

High-quality forage is the key to reducing feed costs. This is done by harvesting and storing a high-yielding, good-quality crop of forage. When a crop such as alfalfa is cut just before flowering and harvested quickly under good weather conditions, protein and energy levels above 25 and 65 per cent are possible. Late harvesting decreases the crude protein content, dry matter digestibility and dry matter intake of the forage.

Stage of Growth

One of the most important factors affecting forage quality is the state of maturity at cutting. Young, vegetative forage is higher in protein and energy than older, flowering material. Quality of first-cut alfalfa drops especially quickly. Producers aiming for a very high-quality forage (for example for dairy cows or cash hay sales) should consider cutting as early as June 10-15.

Relative Feed Value (RFV) is an indicator of forage quality, based on a combination of acid detergent fibre (ADF) and neutral detergent fibre (NDF). For high-quality hay to be fed to dairy cows or sold in the cash hay market, an RFV of 150 is considered ideal.

Handling and Leaf Loss

The feeding value of leaves is considerably higher than that of stems. Loss of leaves in handling decreases feed value. Leaf losses are likely to occur when legumes are cut and raked for hay, but can be minimized by harvesting with a mower conditioner.

Rapid Dry-down of Hay

Large losses in feeding value may result when hay is exposed to weather. Rapid-curing, collection and proper storage of forage reduces these losses. Table 18 summarizes the types and magnitude of losses that may be expected under good management and harvesting conditions. Much higher losses are possible with all systems under fair or poor conditions. These figures are valid only if proper care and management are provided to all harvesting and storage operations.

An Easy Method to Determine Forage Dry Matter

Knowing dry matter content is important when harvesting, or buying and selling forage. Forage dry matter content can be easily determined in a few minutes, using a microwave oven and a small fish or diet scale.

1) Weigh an empty paper plate. **Example weight: 100 grams**
2) Place forage sample on plate — approximately 200 grams — and record combined weight. **Example: 300 grams**
3) place plate and subsample in microwave oven with a cup of water
4) microwave on high for three minutes
5) remove plate and sample, and re-weigh, recording the weight
6) place sample back in oven, and microwave on high for one minute
7) continue heating sample for one minute intervals (and re-weighing) until sample stops losing weight. **Example subsample and plate final weight: 150 grams**

Forage Dry Matter calculation:

$$\frac{\text{(final wt of sample) - (wt of plate)}}{\text{(original wt of sample and plate) - wt of plate}} \times 100 \text{ per cent} = \text{per cent forage Dry matter (DM)}$$

Example: $\frac{150-100}{300-100} \times 100$ **per cent = 25 per cent forage dry matter**

Table 18. Dry matter losses of hay and silage during harvesting and storage.

Dry Matter Losses (per cent)					
	Silage	Silage	Square Bales	Round Bales	Loose Stacks
initial moisture	45%	65%	18%	18%	22%
STAGE					
Respiration and weathering	6	4	10	10	9
Harvesting	3	2	3	5	10
Storage	5a	10b	3c	6d	10d
Feeding	4	4	5	5	5
TOTAL	18 %	20 %	21 %	26 %	34 %

Usual storage method: (a) Steel-tower silo, (b) Bunker silo sealed with plastic cover, (c) Hay shelter, (d) Outside storage

Round Bale Silage

Harvesting silage in round bales can be an economical means of reducing losses when faced with uncertain weather. Benefits include being able to use existing round-bale equipment, and lower field and feeding losses than with dry hay. Because stands with a high sugar content ensile well, best results are usually found with mixed alfalfa-grass stands cut at an early growth stage. Stands receiving rain in the swath should not be harvested as round-bale silage, because the bacteria needed for ensiling cannot compete with soil bacteria splashed onto the forage by rain. Before baling, ensure that bale handling equipment can handle the heavier bales, which can weigh as much as 2,800 lb for a 6-foot bale. Do not cut more in one day than you can bale and stack in a day. Bale at 40-60 per cent moisture. In most cases, this is achieved by baling the day after cutting. Baling too wet results in butyric acid (sour silage) production and increased freezing of the bales, and baling too dry results in greater quantities of air in the bale and mouldy silage. Seal bales in plastic as soon as possible, and always the same day. Storage options include using sheet plastic over a pyramid stack, single-row tube, and tube wrapping, or individual bale wrap. Monitor silage wrap for holes and tape holes shut with duct or construction tape.

Ammoniating Forage

Ammoniation can be used when storing damp hay or to improve the feeding value of low-quality forages. Ammonia (NH_3), which contains nitrogen, increases the protein content of low-quality feed. It further increases the feeding value by assisting in the breakdown of the poorly digested lignin fraction of mature forages.

In addition, ammonia acts as a preservative, allowing forages to be safely harvested at higher moisture levels. Bacteria and moulds are destroyed during the ammoniation process, preventing overheating. This results in a safer and more palatable end-product, with less destruction of plant nutrients during storage. It also reduces field harvesting losses and is less weather dependent.

For a description of the ammoniation process and the safety precautions required, refer to Manitoba Agriculture and Food fact sheet *Ammoniation of Forages*.

Pasture Management

Native Pastures

Native pastures in Manitoba generally yield less than their potential, due to overgrazing. In addition, native pastures are very sensitive to early-season grazing. Grazing before June 1 results in a season-long yield reduction of 40 per cent. Steps to improve productivity of native pastures are:

- keep livestock off native pastures until mid-June;
- take livestock off pasture when they have consumed 60 per cent of a season's growth;
- use rotational grazing to give plants a rest period and allow for more uniform utilization;
- control brush chemically or mechanically;
- use tame pastures to complement native pastures and prevent overgrazing.

Tame Pastures

Using forages that differ in their growth habits can increase the length of the grazing season considerably. Grasses such as crested wheatgrass, meadow bromegrass and timothy begin growing early in the season. Bromegrass, intermediate wheatgrass and alfalfa produce much of their growth in June and July. Using legumes in pastures increases overall yield and quality, and reduces the need for N fertilizer. Alfalfa can be damaged by spring grazing and should not be grazed until late May to ensure its longevity.

Rotational Grazing

Rotational grazing improves pasture production by allowing forage plants a rest period to rebuild energy reserves. Benefits of rotational grazing are:

- increased overall productivity, and desirable species (such as alfalfa) are maintained;
- forage material can be maintained in high-quality vegetative state;
- more even utilization by reducing undergrazing and overgrazing within the same field;
- allowing for hay harvest of paddocks not needed for grazing.

Fertility

Fertility can be used to alter the ratio of grass and legume within a stand. To favour grass, increase the amount of nitrogen applied. To favour the legume component, increase the amount of phosphorus used.

Brush Control

Dense aspen (poplar) regrowth following clearing greatly reduces forage yields. Aspen can be controlled chemically and mechanically. Broadcast-spraying can be effective, but may be expensive and can remove good forage plants. Herbicides applied with a carpet wiper have provided good results. Best results have been obtained using a wiper consisting of a fold of non-rubber backed, indoor/outdoor carpet kept moist by spray nozzles. Mechanical control using a brush drag has also been effective when suckers are mature enough to be broken. Control using a brush drag appears to be best when conducted in June and is improved by two passes, the second at a right angle to the first.

Winter Survival of Alfalfa

Alfalfa stands are a valuable resource, and should be managed to ensure their long-term survival. This is especially true where renovation is risky and expensive, such as on erodible, thin, hilly or stony soil. A number of factors combine to affect the winter-hardiness of a stand:

- **Critical Harvest Period**

  Cutting or grazing schedules are an important factor in determining winter survival of forage stands. In order to reduce the risk of winter kill, alfalfa should not be cut or grazed during a five-week period before a killing frost. This time allows alfalfa to store food reserves in roots and crowns, and increase winter-hardiness.

- **Age of Stand**

  Older stands are more at risk of winter kill than are younger stands.

- **Varieties**

  Some varieties are more winter-hardy than others. Generally, variegated type varieties are more winter-hardy than Flemish types.

- **Fertility**

  Soil fertility, especially potassium (K), is important. Most Manitoba soils have adequate potassium. Sandy soils are most likely to be deficient.

- **Soil Moisture**

  Alfalfa on wet soils during winter is more prone to winter kill than on dryer soils.

Winter-injured stands will show signs of yellowing, slow growth and few stems per plant. Stands may recover if the first cut is delayed until near maturity.

Leaving tall stubble (6") and/or leaving unharvested strips between mower passes may improve winter survival by increasing snow trap.

Special Problems

Bloat

Bloat can occur when ruminant animals are pastured on lush alfalfa or other legumes, such as red clover. It may also occur when animals are fed chopped alfalfa forage in a confinement situation.

Bloat is a distension of the rumen caused by an abnormal collection of gases. During normal digestive processes, large amounts of methane and carbon dioxide gases are produced in the rumen and are "belched up." In cases of bloat, however, the gases are trapped in the digesting food and pressure builds in the rumen, causing the left side of the abdomen to become distended. If relief is not available, the pressure continues to increase until the animal dies, usually by suffocation.

For information on the control and prevention of bloat, refer to the Manitoba Agriculture and Food fact sheet *Bloat in Cattle and Sheep*, Agdex number 400-20.

Prussic Acid

Prussic acid poisoning occurs when animals feed on young or stressed sorghum or sudangrass. Prussic acid accumulates in sorghum and sudangrass that grows rapidly after stress. Do not graze or harvest sorghum or sudangrass before it is 24" tall. If the crop is affected by frost, do not graze until the frozen plant material has dried.

Nitrates

Nitrate poisoning can occur when animals feed on annual forages and, to a lesser extent, on perennial forages. Animals should not be allowed to eat feed containing more than 0.8 per cent KNO_3 (0.5 per cent NO_3). Nitrate levels increase following stress caused by frost, drought, hail and wet, cloudy weather. Following a stress, the plant roots continue to supply nitrate to the plant leaves and stems, which are not capable of using it. The ensiling process will reduce nitrate levels.

Several steps can be taken to reduce nitrate poisoning. Harvest the crop immediately after stress to prevent accumulation. Blending low and high-nitrate feed can dilute the nitrate content. Rumen microbes do adjust over time to higher nitrate content.

High nitrate levels in forages can occur as a consequence of excessive nitrogen fertilizer application. To avoid nitrate accumulation in forages due to excessive nitrogen application, always apply less than 150 lbs of nitrogen per acre in a single application.

Coumarin

Older varieties of sweet clover contain significant amounts of coumarin. In well preserved hay and silage this compound poses no risk. However, in spoiled or partly spoiled sweet clover hay and silage, the coumarin can be converted to a toxic substance called dicoumarol. The presence of this compound causes the blood to lose its normal ability to clot.

Alkaloids

Older varieties of reed canary grass can contain alkaloids which have negative implications for livestock performance when forage from these varieties is fed. Most newer reed canary grass varieties have been bred to be alkaloid free. If seeding reed canary grass, ensure that the variety chosen is a low alkaloid or no alkaloid variety.

High potassium levels

Forage with potassium levels higher than 3% on a dry matter basis have been implicated with the occurrence of milk fever when this forage is fed during the close up period prior to calving. This forage is generally produced on soils either with naturally high levels of potassium fertility or due to excessive manure application rates. Feeding low potassium forage to dry cows is the best way to avoid milk fever. Generally speaking, grass hay, corn silage, and more mature alfalfa will contribute to lower levels of potassium in forage. Low potassium forage can also be produced from soils, which are low or deficient in potassium. Sandy textured soils are more often deficient in potassium than heavier textured soils.

Endophytes

Some turf type varieties of tall fescue and perennial ryegrass can contain endophytes. Endophytes are a fungus that live within the grass plant that can produce toxins that have negative implications for livestock health. If growing a turf type perennial ryegrass or tall fescue for seed, straw residues from this seed production should be tested for level of endophyte toxin present in the straw prior to feeding the straw to livestock. If seeding perennial ryegrass or tall fescue for pasture or hay production, ensure that you are selecting a forage type perennial ryegrass or tall fescue.

ANNUAL FORAGES

Annual forages are useful to complement perennial forage supplies and provide emergency hay and pasture, and to extend the grazing season.

Oats and **barley** are the most common choices for annual forages, because they provide good yield and quality, compared with other cereals. Oats make good pasture, and will regrow if grazed at the boot stage. Seed at 90-120 lb/acre. For green feed or silage, harvest at the soft dough stage for optimal yield and quality. Cereals generally take longer to dry down than hay crops, but make excellent silage.

Corn can produce high silage yields in warmer regions of the province. See the corn section for more information.

Peas produce low yields of high-protein forage if harvested when earliest pods begin to wrinkle. Peas can be seeded with a cereal if a high-protein forage is desired, but the yield of the mixture is reduced significantly, and weed control options are limited. Seed at 1/2 the rate for pure stands, 1.7 bu/acre.

Millet produces good yield under hot, dry conditions, but should not be seeded into a dry seed bed. Siberian (foxtail) millet has higher yield and quality than Proso (grain or crown) millet. Seed shallow (drill to 1 inch, or broadcast and harrow) at 25 lb/acre. Harvest millet at the heading stage.

Fall-seeded **fall rye** or **winter wheat** can provide good fall and spring grazing. Spring-seeded fall rye provides good summer grazing. Seed rye at 1 bu/acre, winter wheat at 1.5 bu/acre.

Annual Ryegrass grows well on a variety of soils. Experience indicates that it is suitable as supplementary pasture from mid-summer to late fall.

ALTERNATIVE CROPS

In addition to major and minor field crops there are some opportunities for alternative crops in Manitoba. Among them are small fruit, vegetable crops and also medicinal and aromatic plants that require more intensive management and production costs that may be higher. The alternative crops below require little in the way of specialized machinery and are similar in management to common annual field crops. However, new growers will face several challenges:

- markets may be difficult to obtain, and price fluctuations may be large;
- small-acreage crops typically have few herbicide, fungicide and insecticide options, so producers must rely more heavily on cultural practices for weed, disease and insect management;
- experience and research with these crops is very limited; therefore, the available production information is often incomplete;
- producers should get a contract to produce most of these crops as markets are small and special considerations when growing, harvesting or processing may be required by buyers.
- Check Manitoba Agriculture and Food's web site for more information on alternative crops in Manitoba at http://www.gov.mb.ca/agriculture/crops/

As markets may be limited, prospective growers should research market prospects before sowing any of these crops. More detailed information on these and other alternative crops is available from Manitoba Agriculture and Food.

Amaranth

Amaranth originates in South and Central America. The North American market is primarily as health food, and demands organically grown seed.

Field Selection and Seeding:

Amaranth can be difficult to establish. It is a heat-loving annual, slow to establish in cool weather, and a poor performer on heavy soils. Seed in mid-May at 1 to 2 lb/acre, 1/4 to 1/2 inch deep in a firm, moist seed bed.

Management:

Fertilize similar to a cereal crop. No serious disease problems have been observed. No herbicides are registered, but amaranth may be grown in wide rows to permit inter-row cultivation.

Harvest:

Swath in mid-September and combine when dry, or direct combine after killing frost. Store at less than 11 per cent moisture.

Borage

Borage is grown to extract oil from the seed. The oil is rich in gamma-linolenic acid (GLA), which has proven health benefits. Production is only under contract. A realistic yield expectation is 200 lb/acre.

Establishment:

Borage is an annual that prefers a cool, moist environment. It tolerates fall frost. Seed in mid-May as late seeding enhances oil content. Seed at 10-12 lb/acre, 0.5 to 1 inch deep.

Management:

Fertilize similar to cereals; adequate fertility enhances flowering. No herbicides are registered, but borage is competitive when established. No serious disease problems have been observed.

Harvest:

Swath in early September, then combine when dry. Shattering is extensive, and optimum swathing time is uncertain. Green seed and foreign material must be cleaned out, and volunteer cereal grains are difficult to separate.

Dill seed

Dill seed is well adapted to Manitoba, but market opportunity currently appears to be very limited. Some dill has been grown to extract oil from the plant tissue, but this requires costly extraction equipment, and the market is limited and difficult to tap.

Field Selection and Seeding:

Dill seed is an annual, best suited to well-drained loamy soils. Sow in mid May at 8-10 lb/acre, 0.5 to 1 inch deep.

Management:

Fertilize to 60 lb N/acre, 30 lb P_2O_5/acre. Dill seed is a poor weed competitor, and no herbicides are registered. Disease risks include phoma and sclerotinia.

Harvest:

Swath at 25-50 percent colour change.

Fenugreek

Fenugreek seed is used in curry powder and has several components that could be of interest in food processing. It is well adapted to Manitoba but the market currently is limited.

Field Selection and Seeding:

Fenugreek is an annual, maturing in 110 days. It tolerates spring frost, but early-fall frost turns seeds black. It is best suited to well drained soils. Sow in early May at 30-45 lb/acre, 1 to 1.5 inches deep.

Management:

Nitrogen fixation tends to be poor, even with inoculation, so N fertilization is required; otherwise, fertilize similarly to peas. No herbicides are registered, and fenugreek is a poor competitor. Disease risks include root rot, powdery mildew and cercospora. Blister beetles and aphids have been observed, but are not known to be serious.

Harvest:

Swath when 50 per cent of pods are yellow, or direct-combine. Store at less than 12 per cent moisture. Best quality consists of sound, golden seed.

Industrial Hemp

Licensing is required for importing and exporting, growing and processing of industrial hemp. A license to cultivate industrial hemp can be obtained through Health Canada, Bureau of Surveillance, by anyone 18 years or older and who has not been convicted of a drug related charge. Producers are required to grow a minimum of 10 acres, and must provide a map of the area indicating the location as well as the GPS coordinates. Licensing information is posted on Health Canada's web site.

Field Selection:

Hemp performs well on a range of soil types, but is intolerant of salinity and poor drainage conditions. Saturated soil may cause stunting, yellowing, and death.

Seeding:

Varieties

Only pedigreed seeds of approved industrial hemp varieties, as listed on Health Canada's List of Approved Cultivars, may be planted.

Dates

Industrial hemp should be seeded when the soil temperature reaches 6 to 8° C, usually early to mid May. Earlier seeding is not recommended because soil temperatures will be too cool for optimum emergence. Hemp varieties are photoperiod sensitive, meaning that seeding date has little effect on flowering date and maturity. Therefore, earlier seeding should result in higher stalk and seed yield potential. In Manitoba, seeding date trials have been conducted at two sites for one year. Results are preliminary and more data is required to reach conclusive recommendations.

Rates

When growing industrial hemp, the decision has to be made whether to grow the hemp for seed or for fibre. The fibre crop is seeded at a much higher rate to achieve long thin stalks. Local and European experience suggests the seeding rate for hemp fibre crop should be 300 seeds/m2. No trials have been conducted in Manitoba looking at seeding rates that would achieve optimum hemp fibre yield.

For a seed or grain crop, the seeding rate should be 100 seeds/m2, which is approximately 20 lb/acre. Initial results from seeding rate trials in Manitoba indicate best seed yields were achieved at seeding rates of 100 seeds/m2.

Depth:

Seeding depth should be as shallow as possible (.75 to 1.25 inches), but into moisture to obtain rapid and uniform emergence.

Fertilizer:

Soil testing is important to determine the amount of available nitrogen present in the soil so accurate recommendations can be made. Fertilizer rate information is limited, but good results have been obtained in Manitoba by using rates of 80 N, 45 P_2O_5, 60 K_2O, and 15 S (lb/acre).

Preliminary results from Manitoba nitrogen fertilizer field trials indicate hemp responds well to nitrogen. Phosphate fertilizer trials show phosphate did increase yields, and sulphur fertilizer trials showed hemp yield may increase with the addition of sulphur on S-deficient soils. Maximum levels of fertilizer that can be placed safely with the seed are not known yet. Further work is required to determine the optimum levels of fertilizer that can be used for industrial hemp production.

Weeds:

There are no registered herbicides that can be used on industrial hemp. However, crop tolerance trials are being conducted in Manitoba. A uniform stand that emerges ahead of weeds is very competitive. Therefore, any production practices such as field choice or pre-seeding tillage/burn-off that helps to ensure the hemp stand will emerge quickly and uniformly will have an advantage over the weed population.

Insects

Bertha armyworm may be a significant pest as it caused significant defoliation of hemp in 1995 trials. Other pests that have been observed but caused minor damage include lygus plant bugs, cornborer, cutworms, stinkbugs, and grasshoppers.

Diseases:

Hemp is susceptible to sclerotinia and yield losses can be significant. Adequate rotation with non-susceptible crops, and management of host species such as volunteer canola are the key approaches to managing disease risk.

Harvesting:

For Fibre

The highest quality fibre is obtained by cutting at early to mid-flowering. Mower/conditioners (with crimping rolls removed) and round-balers may be suitable for low to medium quality end uses.

For Grain

Direct combining when shelling becomes evident is the best approach for harvesting grain. The header cutter bar should run four to five feet above the ground. Care should be taken to avoid dehulling in the combine, since dehulled seed is more prone to spoilage or quality loss in storage. After combining, the remaining stalk material can be cut and baled.

Storage:

A moisture content at which hemp grain can be considered "dry" is not known precisely. Some European literature suggests storage at less than 12 per cent should be safe, while other literature suggests less than 10 per cent. Winter storage at less than 12 per cent should be safe in Manitoba.

Growers should take caution when drying grain since maximum drying temperature to maintain grain oil and meal quality and seed viability is not known. Drying should commence as soon as possible after harvest to ensure quality remains high.

Proso millet

Proso millet is a warm-season annual grass, grown primarily for bird seed. While the value tends not to be high, contracts are available. A cool growing season will result in yields in the low end of the range, while a warm season with adequate rainfall will produce yields in the top of the range. Yield is somewhat variable, in the 1,000-3,000 lb/acre range.

Field Selection and Seeding:

Proso millet matures in 100 to 110 days. It is drought-tolerant but responds to moisture, and is best suited to well-drained soils. Sow in early to mid-May at 20 lb/acre, 3/4 to 1 inch deep.

Management:

Fertilize similarly to cereals, although with slightly less nitrogen than for wheat. No herbicides are registered and proso millet is a poor competitor; delayed seeding has been found to be a useful weed management strategy. No serious disease problems have been observed.

Harvest:

Swath when 50-75 per cent of the panicles are ripe. Green/yellow foxtail seed contamination is difficult to remove.

Quinoa

Quinoa originates in South and Central America. The North American market is primarily as health food, and demands organically grown seed. Quinoa can be difficult to establish.

Field Selection and Seeding:

Quinoa is an annual, maturing in 100 days. It is best suited to well-drained soil. Sow in early to mid-May at 3/4 lb/acre if germination is good, 1/2 to 3/4 inch deep in a firm, moist seed bed.

Management:

Quinoa has a moderate to high requirement for nitrogen; fertilize with 125 lb N/acre. No herbicides are registered and quinoa is a poor competitor. Flea beetles can cause significant seedling damage. No serious diseases have been observed.

Harvest:

Swath mid-September or direct-combine at maturity. Store at 8-12 per cent moisture. Saponin compounds need to be removed by washing or de-hulling before human consumption.

Safflower

Safflower is grown in the Prairies both for bird feed and as an oilseed. While markets in Saskatchewan and Alberta may be difficult to tap, the crop would be well suited to southwestern Manitoba. Earlier-maturing, disease-tolerant varieties are now available to make it a less-risky crop than when Manitoba growers first experimented with it in the early 1980s. A realistic yield expectation is 1,500 lb/acre.

Field Selection and Seeding:

Safflower is an annual, maturing in 120 days, suited to southwestern Manitoba. It performs poorly on heavy soils. The variety Saffire is used for birdseed, while AC Stirling is used for both bird feed and as an oilseed. Safflower tolerates spring frost. Sow in late April to early May at 25-30 lb/acre, 1 to 1.5 inches deep.

Management:

Fertilize to 100 lb/acre N, 30-40 lb/acre P_2O_5; a maximum of 20 lb/acre N and 35 lb/acre P_2O_5 can be seed-placed. Safflower is a poor competitor, but herbicides containing trifluralin and Edge herbicide are registered. Seed treatment may be necessary to reduce risk of damping-off. To reduce disease risk, use a sclerotinia head rot resistant variety and seed tested to be free of *Alternaria*.

Harvest:

Direct-combine at maturity; start when moisture is less than 13 per cent. Safflower is considered dry at 9.5 per cent moisture. Buyers will look for sound, bright white seed.

Spelt

Spelt is a type of winter wheat that is marketed primarily as an organic health food. It is a winter annual, which is subject to winterkill if exposed.

Field Selection and Seeding:

Sow into stubble in late Aug. to early Sept. at 80-100 lb/acre, 1 inch deep.

Management:

Fertilize to 50-60 lb/acre N, 25 lb/acre P_2O_5. No herbicides are registered. Spelt is susceptible to loose smut and bunt. No insect problems are known.

Harvest:

Direct combine at less than 14 per cent moisture, or swath and combine. The hull adheres to the seed.

Medicinal plants

(Detailed fact sheets on commercial production of medicinal plants are available at Manitoba Agriculture and Food offices)

Echinacea

Echinacea (pronounced "ek-a-NAY-sha") is used to prevent and treat the common cold, influenza and other infectious diseases. Echinacea belongs to the Aster family. There are nine species of Echinacea in North America, of these only three have been shown to have commercial significance. These species are *Echinacea angustifolia*, *E. purpurea* and *E. pallida*. Each of these species can be grown in Manitoba. Most Echinacea species have a taproot while *E. purpurea* has a fibrous root system.

Echinacea angustifolia grows to be between 12 – 24 inches with a stiff, coarsely haired stem.

Echinacea is best suited for a poor to moderately rich, well-drained soil. A high lime content is preferred. However, they will tolerate a slightly acidic soil with a pH of 6.0 or greater. Echinacea is drought tolerant. Good soil drainage and frequent, shallow cultivation are necessary to produce more vigorous plants. For root harvest of plants grown from seed, three to four years' growth is required. Autumn is the best time to harvest Echinacea, as the moisture content is normally lower then than it is in spring. Once roots have been harvested they should be cleaned and dried. Two possible methods for drying the roots are under low forced heat, or in open air under heat.

Since Echinacea is sold as both a fresh and dried product, the type and amount of processing is determined by your market and/or contract conditions. Drying of the herb is easily accomplished, however it should be noted that drying at a moderate temperature of 20 – 25° C is preferred.

Feverfew

Feverfew (*Tanacetum parthenium)* is a perennial herb with erect stems growing to 3 feet tall. The leaves are alternate, divided into broad, toothed segments, and have a strong distinctive odour. The flowers are daisy-like, having a central disc of yellow florets surrounded by white ray florets, and form flat-topped inflorescences.

For cultivation of medicinal feverfew it is important to understand that there are at least three types of feverfew that have significant differences in their natural chemistry. These types cannot be distinguished visually, only by chemical testing. Feverfew is believed to have originated in temperate Eurasia, but it is now cultivated as an ornamental and medicinal herb and naturalized as an escapee all over the temperate world. Widely adapted to many situations, it does especially well in dry conditions, and tolerates poor soil. It is found in waste places and along roadsides.

Feverfew does best in average quality, well drained soil of pH 6.0 - 6.7 (6.3 optimum). It prefers full sun or partial shade. It is listed as being suited to hardiness zone 5 but has been overwintered successfully in zone 4 without protection and provision of a mulch cover should allow it to overwinter in zone 3. Feverfew seeds require light for germination, and should be sown on the surface of the soil and lightly tamped in. Seeds should be sown approximately two weeks before the date of the predicted last frost. Germination occurs in 10 - 15 days. Keep the seedlings at a daytime temperature of 18 to 20° C and 10° C at night. Seedlings should be transplanted in June as small clumps of about 5 seedlings when 0.5 to 0.75 inch tall, and spaced 9 to 12 inch apart.

Feverfew should be harvested in the second year by swathing the leaves and flowers while the plant is in full bloom (mid July). Leave 4 inches for regrowth to allow a second cut later in the season. Feverfew should be dried on screens away from direct sunlight for 10 - 14 days. Feverfew leaf, the only part used in registered antimigraine preparations, is used in powdered form, best produced by a shear mill. The leaf material should be stored in a cool, dark area as it has been found that dried feverfew leaf loses at least 20 per cent of its parthenolide content in the first year and more than 50 per cent after two years of storage unprotected from heat and light.

Milk Thistle

Milk thistle (*Silybum marianum*) is an annual or biennial that grows from 5 - 10 feet tall, has large prickly-edged leaves covered with undulating white patches, and stems containing a milky juice. Typically thistle-like, large, reddish-purple flower heads with sharp spines grow at the ends of flower stalks. The fruit is small, hard, shiny, and grey to black (an achene) with a silvery pappus or fluff.

Milk thistle is native to Western and Central Europe and northern India, but has become naturalized by escaping from cultivation in southern Europe, Africa, India, China, Australia, South America, and in many parts of North America. Much of the current commercial seed production for the European market comes from Argentina, while cultivation in Texas supplies some of the U.S. market. Milk thistle is very drought tolerant and prefers dry, well drained soil in full sun. It is found along roadsides, in fields and waste places.

There is evidence of genetic differences between populations of milk thistle with regard to the content of silymarin. Conditions such as rainfall and average temperature also affect silymarin production, with higher temperatures and drier conditions apparently increasing production. Milk thistle is very adaptable to many different growing conditions, but must have well drained soils. Due to its tendency to weediness, site selection should take into consideration containment so that its spread can be controlled if necessary. Seed is sown spring or fall, and takes 2 weeks to germinate. It self-seeds easily. Seeds are ready for harvesting the first year. Mature seeds, which have the highest level of silymarin, are found in seed heads showing abundant silvery white fluff (pappus). Because plants may flower at different times and have different heights, once-over direct harvesting is difficult. Seed heads shatter easily, especially if over-mature in which case as many as half of the total seeds may be lost or have blown away from the centre of the seed head, making handling difficult. Seeds from the edge of the flower head tend to remain on the head late into winter.

Valerian

Valerian (*Valeriana officinalis*) is a perennial that grows up to 5 feet tall. The shoots arise from a short rhizome (horizontal underground stem) 0.8 – 1.6 inch long and 0.4 – 0.8 inch wide, which also gives rise to roots 0.8 – 6 inch long, which are wrinkled lengthwise. and sometimes the plant spreads from horizontal runners (stolons). The roots and fibrous rhizomes have a very strong odour and bitter taste. The stems are hollow and grooved, simple to slightly branched above. The leaves are opposite, deeply divided, with 7 - 10 pairs of toothed leaflets, becoming progressively smaller towards the top of the plant. The flowers, which bloom from June to August, are white or pale pink and fragrant, with irregular tubular corollas often spurred at the base, and three stamens. The inflorescence consists of terminal flat-topped clusters (a corymb). The tiny fruits have a crown of feathery fluff (pappus).

Valerian is a highly variable species which has at least three subspecies and numerous intermediate populations. At least two other species of valerian, *V. jatamansi* (Indian valerian) and *V. edulis* subsp. *procera* (Mexican valerian) are also sold for medicinal purposes. In Manitoba there is also a native species, *V. dioica* L., which is used medicinally by First Nations people. Valerian is native to most of Europe and part of northern Asia, with a complex of subspecies dispersed throughout temperate to subpolar Eurasia. It is cultivated in England, France, Belgium, Holland, Germany, eastern Europe, and Japan. It has become naturalized in the NW and NE U.S. and is reported to occur in Manitoba as an escapee from cultivation. Valerian grows on a wide range of soils, but moist, rich loam with pH 6.0 to 7.0 is best. It is listed as being hardy to zone 4, but has been cultivated experimentally here in Manitoba in zone 3 areas. It likes full sun or partial shade. Direct seeding is done in mid-August, with germination of approximately 80 per cent in about 5 weeks. Seeds can also be started in the greenhouse and transplanted after the last frost. Seeds germinate in about 20 days if started in flats. Light is required for germination, and seeds should be planted no deeper than 0.5 inch. Keep seeds constantly moist (30 - 60 per cent soil moisture content). Stratification does not improve germination. Seeds lose their viability after 2 years. Root cuttings are also possible, but they are subject to many diseases. Roots are harvested after the first frost in the fall of the second season. The tops can be mowed first and the seed collected for planting next season. The roots and rhizomes can then be dug by hand or shallowly plowed. Even the fibrous roots and root hairs should be collected.

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